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MONTANA STATE HIGHWAY DEPARTMENT
HIGHWAY PLANNING SURVEY
IN COOPERATION WITH
PUBLIC ROADS ADMINISTRATION

APPLICATION OF ENGINEERING-ECONOMIC PRINCIPLES TO
DETERMINE FEDERAL AID SECONDARY ROUTING
BETWEEN EKALAKA AND FA ROUTE NO. 23 (US 212)
IN CARTER COUNTY

MONTANA STATE HIGHWAY DEPARTMENT
930 East Lynaale Avenue
Helena, Montana 59601

Released May, 1946



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 Montana. Dept. of Highways. Highway
 Planning Survey. Application of
 engineering economic principles to
 determine federal aid secondary
 routing between Ekalaka and Fa route
 23 (US 212) in Carter county, 1946.

168p. tables

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Montana State Highway Department
Traffic and Planning Section
Public Roads Administration
Basic Design Categories
Table No. 1

Standard	Average Daily Traffic	Classification	Max. Grade	Max. Curve	Sight Distance				Width of Road	Width of Surface	Minimum Type of Surfacing	Minimum Base Course
					Non Passing Vertical	Passing	Shoulder	Width of Bed at Grade				
					Horiz. Curve	Curvature	Feet	Width				
					ature	ature	Feet	Width				
					(Degree)	(Algebraic)						
0	0-200	20 M 40	7	14	14		280	3	24	18	Under 1" Oil	5"
1	201-400	50 M 40	7	14	14		290	4	28	20	2" Oil	6"
2	401-800	100 M 40	7	14	14		310	5	32	22	2 1/2" Oil	8"
3	801-1800	200 M 40	7	14	14		320	6	34	22	2 1/2" Oil	8"
4	1801-3500	300 M 40	7	14	14		330	8	38	22	2 1/2" Oil	8"
5	0-200	20 M 60	6	6	6		460	3	26	20	Under 1" Oil	5"
6	201-400	50 M 60	6	6	6		460	4	30	22	2" Oil	6"
7	401-800	100 M 60	6	6	6		470	5	32	22	2 1/2" Oil	8"
8	801-1800	200 M 60	6	6	6		480	6	34	22	2 1/2" Oil	8"
9	1801-3500	300 M 60	6	6	6		500	8	38	22	2 1/2" Oil	8"

SEE TABLE NO. 2.

Note: Roads having over 3500 vehicles per day require special design.

TABLE NO. 2

Table giving length of vertical curve required for various
Non - passing sight distances

December 18, 1943

Algebraic Difference between grades for convex curvature.	Length of vertical curve for a Non- passing sight distance of: 280 feet	Length of vertical curve for a Non- passing sight distance of: 290 feet	Length of vertical curve for a Non- passing sight distance of: 310 feet	Length of vertical curve for a Non- passing sight distance of: 320 feet	Length of vertical curve for a Non- passing sight distance of: 330 feet	Length of vertical curve for a Non- passing sight distance of: 460 feet	Length of vertical curve for a Non- passing sight distance of: 470 feet	Length of vertical curve for a Non- passing sight distance of: 480 feet	Length of vertical curve for a Non- passing sight distance of: 500 feet
1.00:	96	103	117	125	133	258	269	281	305
2.00:	191	205	234	250	266	516	539	562	610
3.00:	287	308	352	375	398	774	808	843	915
4.00:	382	410	469	500	531	1032	1078	1124	1220
5.00:	478	513	586	624	664	1290	1347	1405	1524
6.00:	574	615	703	749	797	1548	1616	1686	1829
7.00:	669	718	820	874	930	1806	1886	1967	2134
8.00:	765	820	938	999	1062	2064	2155	2248	2439
9.00:	860	923	1055	1124	1195	2322	2425	2529	2744
10.00:	956	1026	1172	1249	1328	2581	2694	2810	3049
11.00:	1052	1128	1289	1374	1461	2839	2963	3091	3354
12.00:	1147	1231	1406	1499	1594	3097	3233	3372	3659
13.00:	1243	1333	1524	1623	1726	3355	3502	3653	3963
14.00:	1339	1436	1641	1748	1859	3613	3771	3934	4268

MONTANA HIGHWAY PLANNING SURVEY
GUIDES FOR ESTIMATING 1960 TRAFFIC

1. 100% = 1941 traffic

Applies to:

2. 110% = Traffic if route is unim-
to proved at present time but
125% expected to be improved by
1960.

F.A., F.A.S. and Class 1, 2, & 3
Forest Highways. Applies to
sparsely settled rural areas.

(Add extra traffic generated by
logging activities on timber
utilization roads or other major
industries and traffic induced by
these activities).

3. 125% = Traffic if route is unim-
to proved at present time but
150% expected to be improved by
1960.

F.A., F.A.S. and Class 1, 2, & 3
Forest Highways. Applies in
checkerboard well-settled rural
areas or on through-roads.

(Add extra traffic generated by
logging activities on timber
utilization roads or other major
industries and traffic induced
by these activities).

4. 150% = Traffic if route is unim-
to proved at present time but
200% expected to be improved by
1960.

F.A., F.A.S. and Class 1, 2, & 3
Forest Highways. This applies in
exceptional cases such as bottle-
necks and natural cutoffs. Some
cases, of course, might be much
more but these special conditions
would require special analysis.

Note: Date of expected improvement
does not change traffic
estimates for 1960.

(Add extra traffic generated by
logging activities on timber util-
ization roads or other major
industries and traffic induced by
these activities).

130% = expected secular growth 1941 to 1960 -- to be applied to all above

Applies to all roads now constructed.
(Without any of above increases)

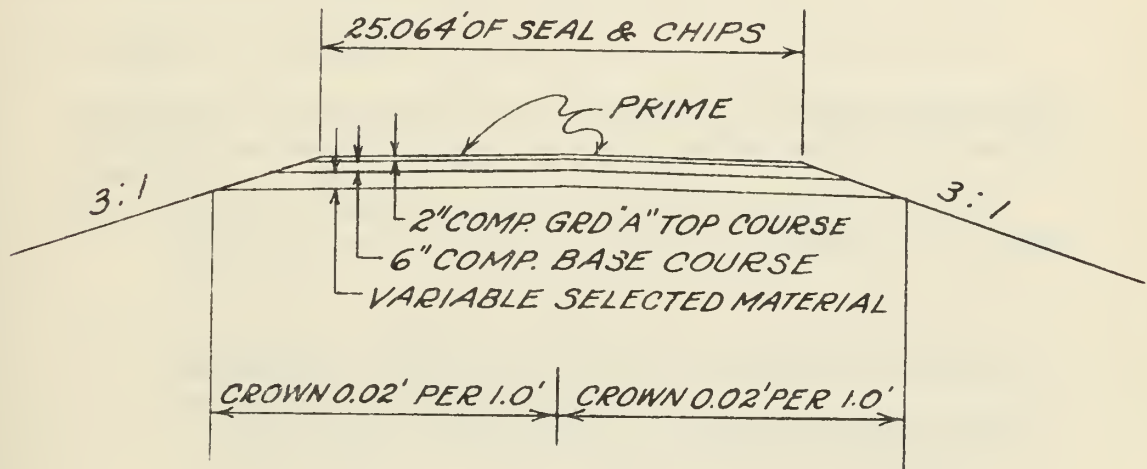
conditions except traffic
generated by logging activities,
or other major industries.

Average summer maximum traffic equals double average ADT except on predominately
recreational routes where factor might be as high as 3.

Average summer maximum traffic equals average of several maximum summer days.
Maximum hour equals 10% of maximum summer ADT. (Usual public traffic), or
15 to 20% on roads used by both the public and by major logging operations
or other major industries.

SECONDARY SYSTEM

100 VEHICLES AND LESS THAN 200
AV. 24-HOUR TRAFFIC



UNDER 100 VEHICLES
AV. 24-HOUR TRAFFIC

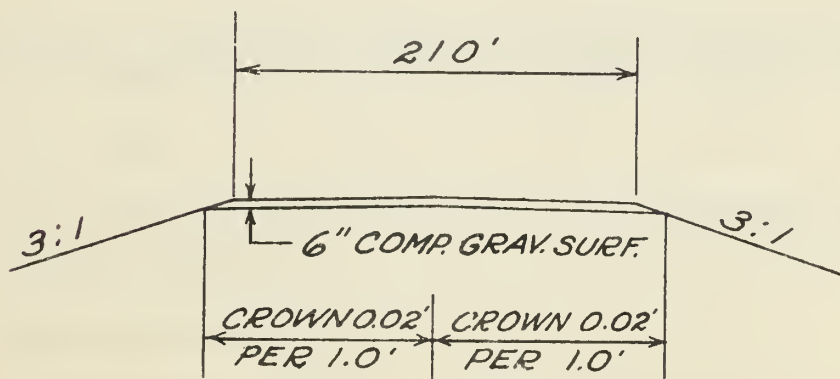


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That the central routing be followed in the designated secondary location and that the Chalk Buttes-Ekalaka road be given first consideration in the allocation of county funds.

APPLICATION OF ENGINEERING-ECONOMIC PRINCIPLES TO
DETERMINE FEDERAL AID SECONDARY ROUTING
BETWEEN EKAŁAKA AND FA ROUTE NO. 23 (US 212)
IN CARTER COUNTY

I. SUMMARY OF FINDINGS

The economic analyses which are set forth in Section IV of this report would indicate that the Ekalaka-FA No. 23 routing should be so located as to pass through Belltower, Ridgeway, Albion and Alzada to effect a connection with US 212 thereby establishing a generally accessible roadway through the center of Carter County along its north-south axis. County-feeder roads could then be built to widen the "service" scope of the Federal Aid Secondary routing and thus approach a "road service" optimum in the county.

This declaration is premised on engineering-economic findings deriving from detailed analyses of five of the ten possible routes lying between Ekalaka and FA No. 23 (Primary). In making the several analyses we had to presume on the continuity or evolution of traffic between stated and established terminals to allow us to arrive at comparable bases. For example, if we were to close an analysis on the junction with FA Route No. 23 in Hammond, we would have answered the requirements of this study insofar as arriving at a connection with FA Route No. 23 is concerned but the study would lack conclusiveness in that we could not compare the routing with any other routing ending in Alzada or Broadus. These towns, both on FA Route No. 23, are control points, so to speak - any problem involving a connection with FA Route No. 23 comes within the scope of the trade-transport influence of the two towns. Accordingly seven of these routings comprehend terminals at Alzada; two by way of Hammond, two via a point 7.0 miles northwest of Alzada on FA Route No. 23 and three by way of Albion, two of which passed through Ridgeway and the other through Capitol. Three of the routes considered ended in Broadus, Powder River County; one by way of Chalk Buttes and a comparatively direct line therefrom to Broadus, one by way of Chalk Buttes to Pinele and a connection nearby on FA Primary Route No. 23 and another by way of Pinele and Vannette's Reservoir along Pilgrim Creek to Broadus. All three of these latter mentioned routes were eliminated in the study, because of the low traffic volumes manifest, particularly between Chalk Buttes and Broadus in the first cited instance and between Chalk Buttes and Pinele in the second cited instances. Nor is there much reason or basis in fact to believe that there would be a significant volume of "interior diversion" to the routings should any one of them be built - the routings range too far west of the principal lines of communication in Carter County to facilitate such diversion. By the same token, none of the three routings would be overly attractive to "outside traffic", Montana and out-of-state, which might want to divert to an interior routing to east-central Montana, the Glendive-Sidney area, for example.

Of the seven routes which comprehended terminals in Alzada, one by way of Chalk Buttes and Hammond followed, from Ridgeway to Hammond, a route interval which would be covered in an analysis of another routing extending from Ekalaka to Sykes Bridge to Ridgeway to Hammond and thence to Alzada.

Details of such an analysis would be of no great moment since the data would repeat that set forth in Analysis "A" as we have labelled it in this study, (Ekalaka - Sykes Bridge - Ridgeway - Hammond - Alzada). Another routing, Ekalaka - Sykes Bridge - Ridgeway - Hay Creek and a point on FA No. 23 seven miles northwest of Alzada could be covered advantageously by an analysis of a routing extending from Ekalaka to Chalk Buttes to Ridgeway to Hay Creek, etc. By so allocating analyses in the study, we have thus twice given direct consideration to the possibilities of routings through Chalk Buttes along with three - fold considerations for routings through and over Sykes Bridge to the east. This we deem to be a fair and impartial allocation when we consider that the principal lines of interior traffic flow in Carter County now range to the east of the central portion of the county in that area between Ekalaka and Alzada. As a "by product" of such allocation in the analyses we can rest assured that we will cover all the essentials of highway economy in the area under consideration - no routing will suffer by reason of insufficient study in reference to its economic worth in whole or in part.

A. ECONOMIC ASPECTS

The declaration set forth in Section I, SUMMARY OF FINDINGS, is the recommendation that a highway-economist would make were he to base such a recommendation on highway economics alone - it being established that the recommended routing had the highest composite solvency rating. In this case, the preferred routing has a composite solvency rating of 0.76 as compared to 0.73 for a routing extending from Ekalaka through Capitol and Albion to a connection with FA No. 23 of Alzada, - these are the highest ratings established in the course of study involving analyses of the five different routings between Ekalaka and Alzada.

A layman, in this particular case, the proponent of the Little Missouri routing through Capitol, might question a routing preference based on a spread of but three-hundredths. He might say that there are possibilities of error or departure from the true facts in the application of the various mathematical formulas which are used to develop the composite solvency rating. The highway-economist would be the first to admit that error might be present in the compilation of statistical reports - as a matter of fact, several of his brethren, and he himself, spend a good part of their time in rooting out and setting up the "standard error" in the course of applied research, be it highway work or the manufacture of plastic girdles. The economist would feel perfectly assured that use of developed formulas on a comparative basis will give him true results because the error, if any, will be spread uniformly throughout his calculations - he knows, from experience, that the standard error will be equally effective over a series of analyses as long as there is a true relationship in the basic data involved in the several analyses. Without going into detail it is asserted here and now that the condition of "true relationship in the basic data" is apparent, and obvious as it affects the Carter County road problem. The central routing, therefore, enjoys a real and tangible preference rating over the Little Missouri Routing on the basis of applied highway economic research - although the "pull" is but three-hundredths it represents a certain superiority insofar as traffic service and benefits are concerned.

B. ENGINEERING-ECONOMIC ASPECTS

It might be well to state the Carter County Secondary Road problem and such other conditions which impinge in the solution of the problem.

Appropriations have been made in the Congress to allow the designation and construction of a Federal Aid Secondary System of highways - responsibility for the route location in each county rests with the Boards of County Commissioners, the State Highway Commission and the Public Roads Administration. These several agencies, operating in consonance, attempt to provide, within the limits of funds available, a system which is inter-county in general aspect while serving the greatest number of people in each of the several counties affected.

Carter County, while lacking in a comprehensive county-wide system of "all-weather" roads is certainly "road minded"; so much so, that its residents by popular vote have approved issuance of \$200,000 in bonds to be used to construct, improve and maintain roads and bridges in the county and to purchase equipment and supplies for that purpose. This action, coming as it does at a time when the County-State-Federal agencies are faced with the problem of designating the best routing between Ekalaka and FA No. 23, makes it incumbent on these several agencies that this county appropriation and the favorable affect of such action be considered in the solution of the Carter County road problem. It is to be remembered that the county monies (bonds) will be used to improve those county roads and bridges on routes which feed to the designated Secondary System.

1. ESTABLISHED CONDITIONS OF THE CARTER COUNTY PROGRAM

Conditions which enter in the solution of the problem are as follows:

a. Since the approval of the \$200,000, bond issue was by popular vote, it is reasonable to think that these funds will be programmed to be expended on an areal basis. Eighty-four percent of the area of the county - that part which is affected by the final designation of the secondary system - lies south of Ekalaka. Accordingly, \$168,000 might be said to be available in conjunction with Federal funds in the furtherance of the County - State - Federal program of Secondary "County-Feeder" construction between Ekalaka and a connection with FA No. 23, at Alzada.

b. Travel habits in the county are dictated by the ruling economy, stock raising, and to a lesser degree the geographical location. Those people resident in the Hammond - Pinielle area transport stock through Alzada to Bellefourche, South Dakota or through Broadus to Miles City, Montana. They rarely make trips to Ekalaka except in those cases attaching to "county" affairs - insofar as their economic environment is concerned they are well provided with roads and their lot will be no less favored when a direct through route is built from Alzada to Ekalaka. Residents of the Chalk Buttes area have their principal outlet through Ekalaka as do those people resident in the Belltower-Ridgeway territory - in short the Albion-Alzada extremity is not of the greatest concern to them. The sparsely populated area in the vicinity of Capitol on the Little Missouri River will probably continue to trade at Camp Crook, South Dakota. In fact and in practice, there is very little north-south communication between the two principal towns of Carter County, Ekalaka and Alzada. But there is "off system" traffic in each of these cited areas which must be considered in allocating "county-feeder" mileage.

c. At the present writing, there are 9.6 miles of gravel-surfaced

roadway extending southeasterly from Ekalaka - this construction represents the expenditure of public funds in the amount of \$124,447. In the analyses which are presented in Section IV, no accounting of these expenditures was made in the computation of annual capital costs for each routing which included this particular section. This for the reason that anticipated benefits as of 1960, were calculated in reference to the surface status as of the present, 1946. Had we chosen to take benefit credit for a surface type improvement from "unimproved" to "oil surfaced" for the 9.6 miles interval we would have realized benefits far in excess of those listed in the analyses. By the same token, we would have had to assess the section with the original cost when capitalized on an annual basis but the increase in benefit values would have operated to show the section in a more favorable light than that set forth in the analyses. This comes about by reason of the fact that a benefit credit for a surface type improvement, "unimproved" to "oil surfaced", is about 60% greater than that manifest when the improvement involves a change from "gravel surfaced" to "oil surfaced".

The same principle applies in the matter of distance saved; we do not know of nor would we care to venture a guess as to the distance saved as a circumstance of construction dating back to 1934. It is reasonable to believe however, that this benefit feature would have operated concurrently with the surface type improvement (unimproved to oil) to render a higher composite solvency rating even though the original construction costs had been added to those now required for re-construction and new construction to bring the section, 18.5 miles, to an "oil surfaced" standard.

Ignoring for the moment the economic principles involved in the omission of the 1934 - 1940 construction costs, we would say that previous expenditures of a considerable sum of money, \$124,447, on any given section of a routing would recommend inclusion of that section in the Ekalaka-FA No. 23 routing. This is just plain "horse sense"; the road section has given good traffic service in the past and as shown in the several analyses, we can expect it to render good service in the future.

d. Last but not least, we have the bridge problem confronting the county. By report of Messrs. Poore, and Wilcomb, State Highway Department and Public Roads Administration respectively, we find the bridge situation in Carter County to be in a deplorable state. Their remarks are quoted as follows - "With the exception of the steel bridges on Box Elder Creek and Little Missouri River, which are all in fair condition and probably safe for ten-ton loads and Federal Aid Built timber bridges, all bridges in this region are in poor condition and require early replacement. Most of them are obsolete as well, the roadway seldom exceeding 15 feet on any bridge." Along all the routes considered in subsequent analyses, there are thirty-five such bridges as those cited in the quoted remarks. They must all be replaced shortly if the county is to maintain and keep operative an integrated "Secondary - County-Feeder" road system. Another point of interest which may be drawn from the quoted remarks - the steel bridges will be satisfactory for continued use "as is" if they form a part of some "county-feeder" route leading to the designated secondary routing. These steel bridges will have to be replaced if they form a part of the designated secondary routing.

The situation boils down to a consideration of which agency or agencies is the better qualified by experience and training to build bridges. Obviously, the State-Federal agencies by reason of long practice should be assigned the job of bridge building to the limit possible in any continuous

secondary routing. Bridge construction expenditures along any of the five routes analyzed, with the exception of those proceeding through Chalk Buttes, are of considerable moment in the Carter County road problem. If the State-Federal agencies build a large footage of the bridges, the County will have more money available to build roads. If on the other hand the State-Federal agencies build a lesser footage of the bridges, the County would be restricted as to the road mileage it might build.

Another peculiarity of bridge construction is that the traffic benefits accruing as a result of such construction are not readily discernible; construction of a hundred feet of roadway returns traffic benefits in the same measure as does an equal footage of bridge construction although the road construction costs might be 1/50 as great as the bridge construction. So, to make the best showing for \$168,000, (84% of \$200,000) spent, the county had better devote its funds to road construction as much as possible.

C. THE CARTER COUNTY ROAD PICTURE

Drawing on certain data developed in Section IV of this report and adding other considerations set forth in the previous discussion we have results as follows to lend weight to the choice of the central routing as the preferred location of the Ekalaka-FA No. 23 secondary road. Explanatory notes thus, 1/, 2/etc. follow the tabulation. On reference to the tabulation, page 6, we find that engineering-economic factors emphasize the preference rating of the central routing. It is further shown that the central routing in combination with a rational "county-feeder" allocation will render the greatest traffic service to the residents of Carter County.

Now to enter into the details of the economic analysis in support of the above statement.

II. ROUTE DESCRIPTIONS

These analyses will treat in detail with five routes designed to serve traffic bound for, through, or from Ekalaka and/ or a connection with FA No. 23 at Alzada, details of the routings are as follows; (See map, frontispiece):

Other routes involving Broadus as a terminal will be described herein as a point of information although, as set forth in the SUMMARY OF FINDINGS, the routings were eliminated from detailed consideration in the study.

A. EKALAKA-ALZADA, Primary routing, FA No. 23 from Hammond to Alzada and Secondary routing FAS No. 323 extended, from Ekalaka to Hammond. This routing originates in Ekalaka then proceeds southeasterly to Sykes Bridge on Box Elder Creek, thence southwesterly along the course of Box Elder Creek through Belltower and Ridgeway, to a point on Federal Aid Primary routing No. 23 near Hammond. From this point to Alzada a distance of 29 miles the routing follows the present primary highway.

The northerly 9.6 miles of the routing were improved to acceptable Secondary standards in the period 1934 -40. This road is surfaced with gravel to a depth of 5 inches and has been maintained in a satisfactory manner during the past several years. From the southerly end of the

COST - BENEFIT COMPARISON CARTER COUNTY

FEDERAL AID CONSTRUCTION							SUPPLEMENTARY COUNTY CONSTRUCTION							COMBINED FEDERAL AID - "COUNTY-FEEDER" ROAD CONSTRUCTION						
1/ AN AL Y S I S	2/ ROUTE DATA		3/ TOTAL ANNUAL CAPITAL COST		4/ ANNUAL BENEFITS		5/ COM- POSITE SOLV- ENCY C/O- TIENT		6/ RATIO BENE- FITS TO COSTS		7/ FEEDER ROAD DATA		ANNUAL CAPITAL COSTS			ANNUAL BENEFITS	COMPOSITE			
	Miles	Tbr. Brs.							Miles	Tbr. Brs.	Road way	Timber Bridges	Maint- enance	Total	TOTAL ROAD MILEAGE		TOTAL ANNUAL CAPITAL COST	TOTAL ANNUAL BENEFITS	RATIO BENEFITS TO COSTS	
A	94.0	20	\$68,318	\$40,595	0.57	0.59	31.2	15	\$5,000	\$5,769	\$1,560	\$12,329	\$29,123	125.2	\$80,647	\$69,718	0.86			
B	80.5	12	\$72,618	\$58,959	0.73	0.81	12.0	23	\$1,923	\$8,846	\$600	\$11,369	\$9,120	92.5	\$83,987	\$68,079	0.81			
C	76.5	17	\$73,982	\$63,437	0.76	0.86	24.0	18	\$3,846	\$6,923	\$1,200	\$11,969	\$17,344	90.5	\$85,951	\$80,781	0.94			
D	83.0	8	\$67,444	\$48,307	0.64	0.72	2.4	27	\$385	\$10,384	\$120	\$10,889	\$1,346	85.4	\$78,333	\$49,653	0.63			
E	80.0	6	\$72,543	\$53,768	0.655	0.74	0.0	29		\$10,769		\$10,769		80.0	\$83,312	\$53,768	0.45			

8/ 9/ 10/ 11/ 12/

1/ See map in the prefatory assembly for location of each routing.

2/ The estimated route length of each routing as of completion, along with the number of timber bridges required to effect that completion.

3/ Total annual capital cost to include interest charges on construction items and annual maintenance costs. See analyses, Section IV.

4/ See analyses, Section IV.

5/ See analyses, Section IV.

6/ This column shows the ratio of benefits to anticipated expenditures. In this regard the central routing still holds to a lead insofar as preference is concerned.

7/ In which the county funds are resolved into an annual capital cost. To render an accounting in column 16/ we must make certain assumptions in regard to the county supplementary or "county-feeder" work, these being:

a. The county will replace all timber bridges not replaced in the course of the Federal Aid Secondary construction at a unit cost equivalent to that estimated for the Federal Aid Secondary timber bridge construction.

b. Out of monies available after the county bridges have been replaced off the designated secondary system, the county will improve important "county-feeder" roads at a cost rate of \$2,500 per mile. This cost rate was assumed with the idea in mind that the county road work on "county-feeder" roads will operate to "get the people out of the mud" - hence it might be classified as construction - maintenance with a significant decrease in costs as compared to standard construction costs.

As an example, let it be assumed that Routing A has been built by use of Federal Aid funds - 20 timber bridges will have been replaced leaving 15 for the County to replace on various "county-feeder" roads of the county road system. The initial cost of such construction will be \$90,000 leaving \$78,000 available for road construction by the county, this value divided by the assumed cost per mile gives us the total road mileage which might be constructed by the county road building agency.

8/ The total cost of road building, \$78,000 in the example hereabove, resolved into an annual capital cost which comprehends interest charges at 2%, the total debt to be amortized in 20 years.

9/ As above.

10/ Assume maintenance costs to be \$50 per mile per year for all that "county-feeder" road constructed by the county.

11/ The sum of columns 8/ through 11/.

12/ Assign benefit values to the "county-feeder" roads in the same measure per mile as found in the several analyses, Section IV.

As a continued example let us say that in connection with Routing A construction, the county will have built a "county-feeder" road from Chalk Buttes to Ekalaka and from Albion to Alzada. The benefits accruing to the Chalk Buttes road will be \$14,820 and those accruing to the Albion - Alzada road will be \$14,303, total value \$29,123. In connection with the construction of Routing "C", the County might build from Chalk Buttes to Ekalaka, 19.5 miles and a 4.5 mile stub leading toward Canitol from Albion. The total benefits thus accruing in the latter example as a circumstance of the "county-feeder" road construction would be \$14,820 plus \$2,524, total \$17,344. It is to be noted that the analyses throughout indicate the high priority of the Chalk Buttes - Ekalaka road insofar as "county-feeder" road construction is concerned.

13/ "Miles", column 2/ plus "Miles", column 7/.

14/ Column 3/ plus column 11/.

15/ Column 4/ plus column 12/.

16/ Here we find an adjustment in ratings, Routing A, formerly fifth as regards solvency and benefit ratings is now second while Routing B has slipped to third. Routing C has emphasized its claim to first choice by assuming a lead of 0.08 over the Routing A and 0.13 over Routing B, its former close competitor.

improved section to Sykes Bridge the road will require gravel and oil surfacing, from Sykes Bridge to the junction with US 212 a distance of 47.5 miles the route will require improvement to the standard set forth in the lower half of the typical sections set out on page iv of the prefatory assembly. This improvement, over all, will necessitate the construction of 2 steel bridges and 20 timber bridges, total length 1,400 feet. Due to the high volume of traffic (105 vehicles per day per mile) over the first 18.5 miles it will be necessary that a bituminous wearing surface be constructed. That section of the routing lying between Hammond and Alzada on FA Route No. 23 is presently surfaced with a bituminous wearing course.

B. From Ekalaka southeasterly (over Route A, as described herebefore) to Sykes Bridge on Box Elder Creek, a distance of 18.5 miles, thence southeasterly via Capitol along the course of the Little Missouri River through Albion to Alzada, a distance of 62 miles. Here as set forth in sub-paragraph A the first 18.5 miles will require bituminous surfacing. From Sykes Bridge to Albion, a distance of 47.5 miles a 6 inch compacted gravel surface course will suffice to serve traffic estimated at less than 100 vehicles per day per mile. The last 14.5 miles extending from the point cited immediately herebefore, higher traffic volumes, (100 $\frac{1}{2}$ vehicles per day per mile), will require construction of a bituminous surface course. Construction of the routing throughout will require the erection of 14 bridges, 2 steel, total lineal footage, 970.

C. From Ekalaka over Route A to a point three miles south of Ridgeway, a total distance of 42 miles, thence through Albion and over Route B to Alzada, total distance over all, 80 miles. The northerly section of the routing and that interval lying between Albion and Alzada will require a bituminous surface course, gravel surface will suffice for the balance of the routing, 43.5 miles. Construction of this routing will entail the erection of 21 bridges, 4 of them steel.

D. From Ekalaka southwesterly through Chalk Buttes and Ridgeway thence over Route A to a point near Hay Creek thence to a point 7 miles northwest of Alzada on Federal Aid Route No. 23, thence to Alzada, a total distance of 83 miles. Construction of this routing will entail the erection of 8 bridges, one of them steel and the balance timber.

E. From Ekalaka southwesterly through Chalk Buttes, Ridgeway and over that portion of Route C lying between Ridgeway and Albion, through Albion and over Route B to Alzada. To conform to current traffic density standards it will be necessary that this routing be oil surfaced from Ekalaka to Chalk Buttes, a distance of 19.5 miles and as stated herebefore, from Albion to Alzada, a distance of 14.5 miles. Should this routing be constructed it would be necessary that 8 bridges be erected, 2 of them steel.

F. From Ekalaka southwesterly through Chalk Buttes to a point 4.0 miles south thereof, a distance of 23.5 miles; thence southwesterly to a point about 3.0 miles northwest of Vanette's Reservoir in Powder River County, a distance of 21.5 miles; thence by way of existing county roads to Broadus, a distance of 15.5 miles; total length 60.5 miles.

G. From Ekalaka southwesterly to a point about 9.0 miles south of Chalk Buttes, a distance of 28.5 miles; thence to Pineale and a junction with

FA Route No. 23, a distance of 53.5 miles; thence by way of FA Route No. 23 to Broadus, a distance of 28 miles; total distance 81.5 miles.

H. From Ekalaka to Piniele as described in "G", a distance of 48.5 miles; thence by way of existing county roads past Vannette's Reservoir to a point 3.0 miles northwest thereof, a distance of 13.0 miles; thence westerly by way of existing county roads to Broadus, a distance of 15.5 miles; total distance 77.0 miles.

There are no special conditions of topography imposing on the construction of any of these routes. In general, the terrain may be described as gently rolling throughout, this is varied somewhat by a range of low but quite rugged hills in the north central portion of Carter County, lying south of Ekalaka and by less rugged hills running northeasterly between Box Elder Creek and the Little Missouri River. Principle drainage courses flow northeasterly in that area covered by these analyses.

The climate throughout is somewhat forbidding, varying from extreme cold in the winter to high temperatures in summer with occasional strong winds; rain fall is quite light not being sufficient for reasonably safe "dry" farming.

III. TRAFFIC DATA

Traffic and vocational pursuits are inter-related to a remarkable degree - given an economy which has suffered by virtue of "hard times" one will find a significant decrease in traffic volumes; given prosperous time one will find a significant increase in traffic. It is not claimed that there is a true dollar-for-dollar relationship in the two variables, economics and traffic. However, the relationship is binding, enough for us to say that traffic records are indicative of economic trends and that fluctuations in such records are evidence of similar rise and fall in the economic pattern of the area being studied. By so treating with the economy of the area along any given routing we thus avoid manipulation of ponderous business and production statistics; our traffic records will suffice. It remains for us, however, to label the existing traffic and that which might develop in the future in terms of the economic function which prompts or might prompt such traffic.

Here, as in other rural areas of Montana the economy is based chiefly on agriculture, stock raising, cattle and sheep, in the main. There are two principle towns in Carter County; Ekalaka, population 475; and Alzada population 179. Ekalaka is the principal trading point for the northerly section of the county. It is also the county seat and the educational center of the county. It lies 38 miles southwest of Baker, Montana, its nearest railroad shipping point on the Milwaukee Railway. All stock raised north of Box Elder Creek and in the Belltower area are trucked or driven through Ekalaka to the rail head at Baker. All stock, generally speaking, raised south of Box Elder Creek and in the vicinity of Capitol are transported or driven through Alzada to the railroad shipping point at Bellefourche, South Dakota which point lies some 33 miles southeast of Alzada on US 212.

Since the routes proposed for analyses tap a stock raising region, as cited heretofore, we can expect a relatively low level of traffic volume in the years to come. However, this traffic will be fairly constant and sustained through the lengths of the routes being studied.

It is a possibility that at sometime in the future any one of the routes chosen for construction will serve a significant volume of diverted

traffic, i.e. traffic which now uses US 212 to Miles City and US 10 to Glendive as a general control. In addition to this particular category of diverted traffic there is traffic, inter-county and intra-county, which in periods of inclement weather, uses US 85 in North and South Dakota and US 212 in South Dakota and Wyoming in the course of travel to and from Ekalaka, the county seat of Carter County. In token recommendation of this possibility and in consideration of the meager data at hand - we have estimated that as of 1960 there will be 6 vehicles per day which will divert to any given route as proposed to benefit by reason of time and distance savings. By so allocating diverted traffic in such small quantity we will not unbalance the analyses in so far as the rural road requirements of the Carter County residents are concerned, while still giving recognition to the possibility of "outside" traffic in the future. Given a situation where any one of the routes would be built there is this further possibility, that local traffic will divert to the improved routing and this feature of traffic development has been recognized in all phases of the analyses which follow this section.

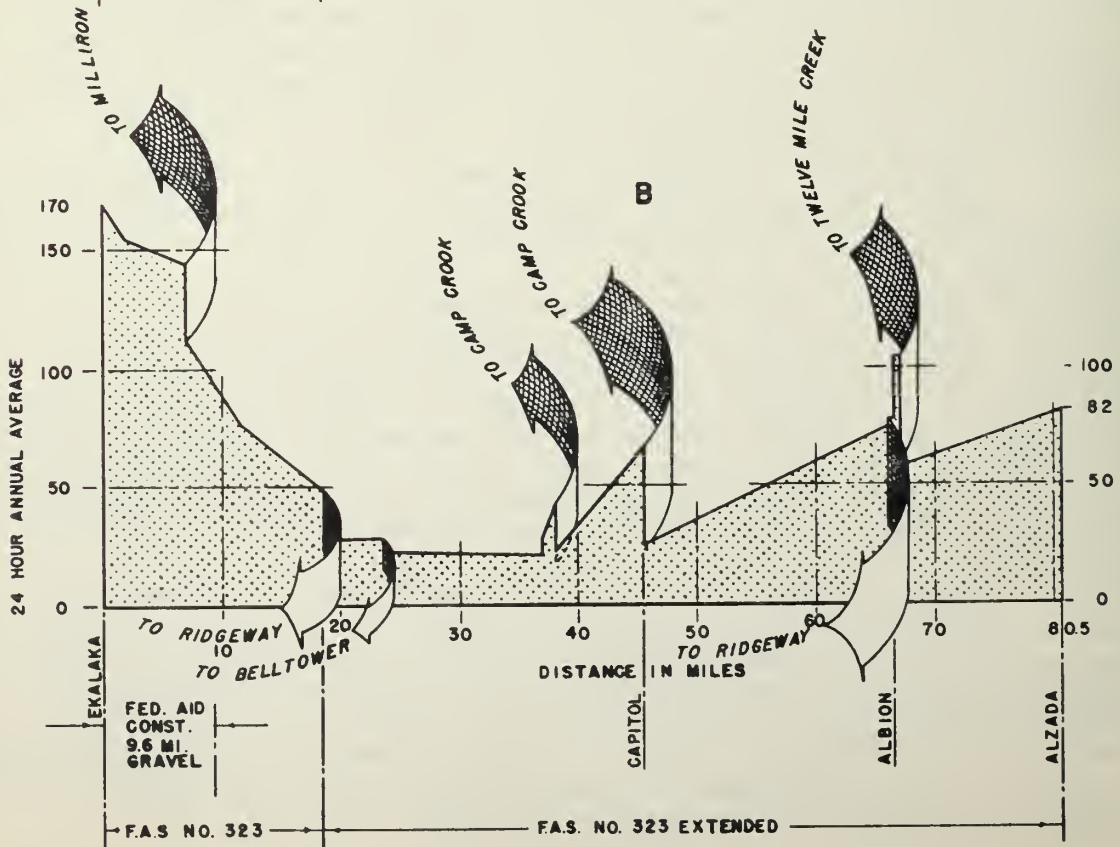
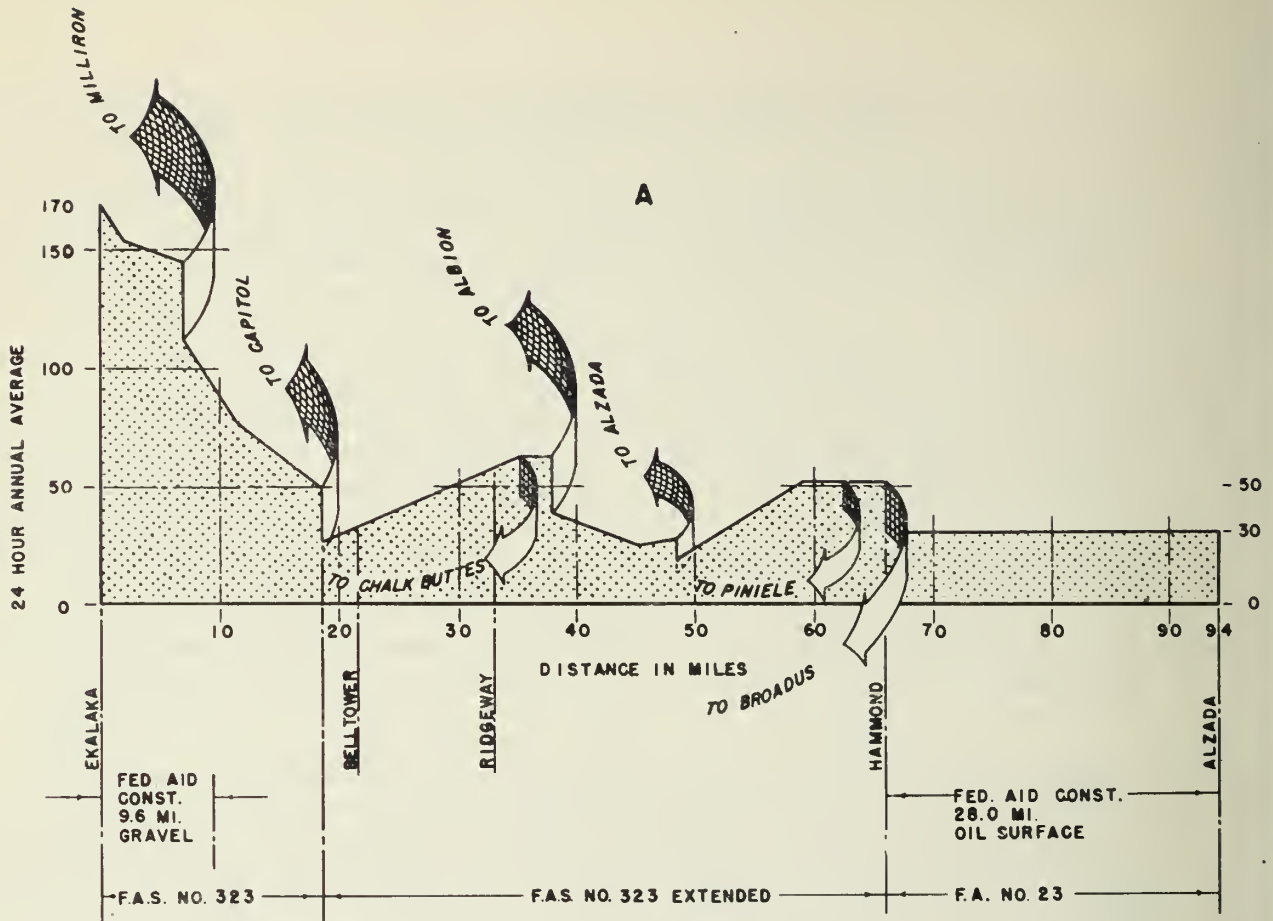
Traffic profiles of each routing as described in Section II are shown on pages 10 through 12. These are comparative profiles and ignore for the moment, that interior diversion mentioned immediately herebefore and the "outside" diversion which might obtain at some time in the future.

On reference to the traffic estimation guide in the prefatory assembly it is found that an increase of 50% in traffic on completion of a through route and 30% in consideration of normal traffic growth may be allowed when expanding present day values to probable future values. These factors, when applied simultaneously have the effect of doubling the Existing Traffic (1941 Traffic) in this case, hence when reading the traffic profile one may ascertain the present day traffic volume by halving those values shown on the charts. It is believed that these increase factors are comprehensive and liberal enough to allow for any basic change in the ruling economy of the region which might prompt increased driving by the residents of the southerly half of Carter County.

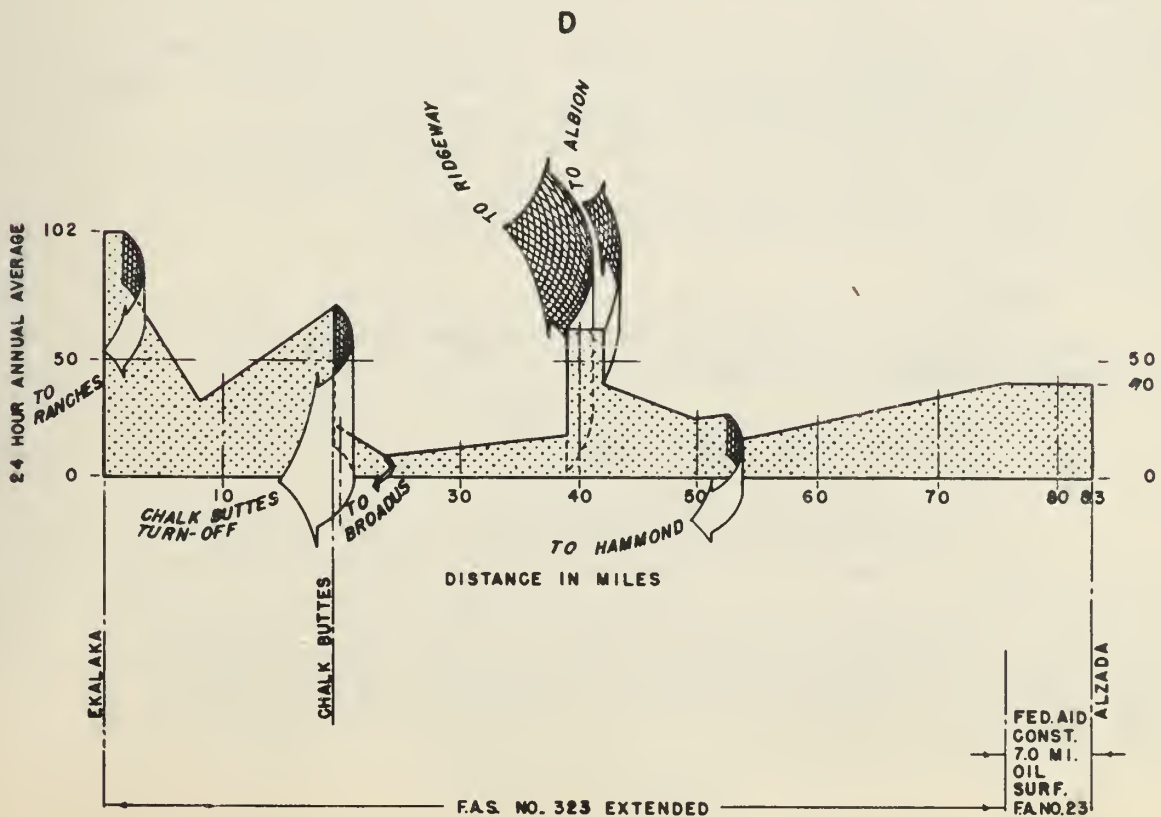
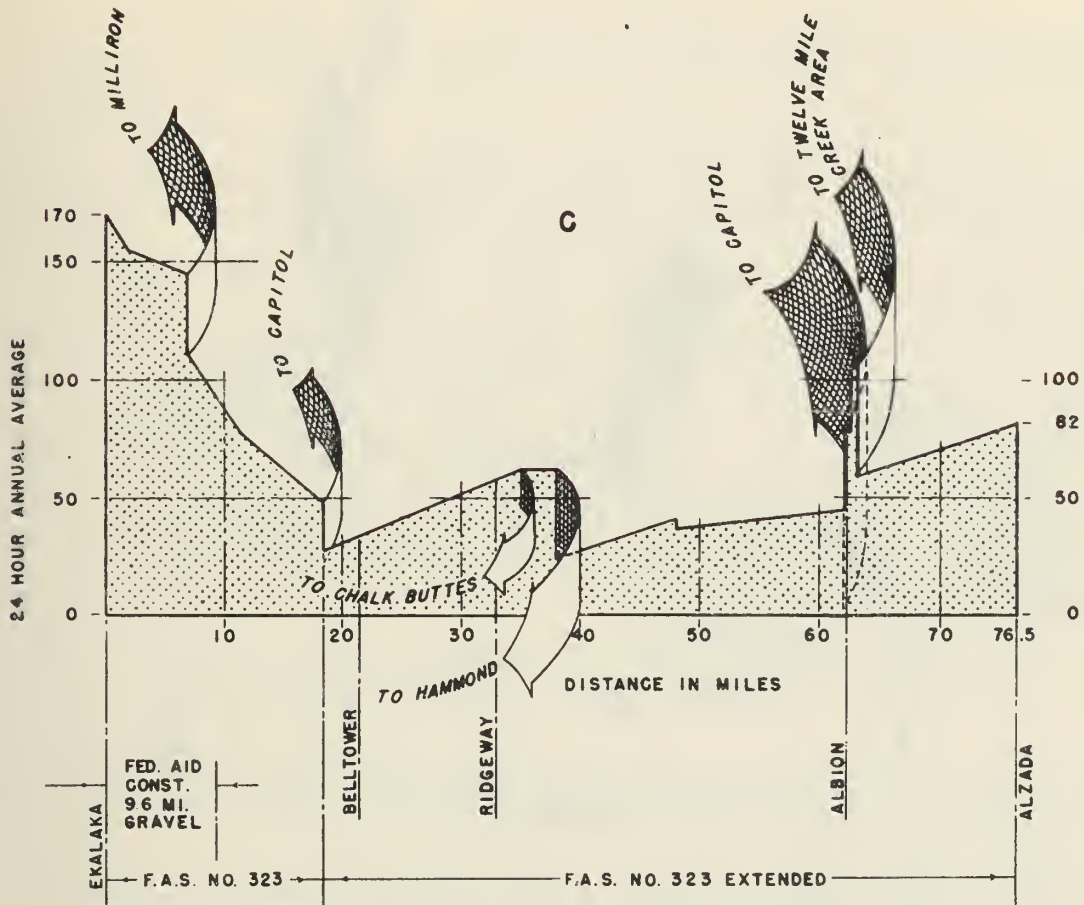
The traffic profiles are drawn with a view to illustrating the flow and direction of traffic. As an example, let us take profile "A" - beginning at Ekalaka and proceeding towards Alzada we come to the first indication of a significant drop in traffic volume at the Milliron turnoff. The arrow indicates that this is a left turn because it points away from us as we read the profile. Now if we scale the vertical distance either at the traffic break or just behind the "ears" of the arrow-head we will thus measure the volume of traffic on the Milliron road at the point at which it leaves Routing "A". Since the arrow is in full relief we can assume that traffic on the Milliron road flows through the junction between some points on the Ekalaka-Milliron routing - there is no traffic, at least not a significant volume, which will enter on Routing "A" to go south or leave Routing A to go east towards Milliron.

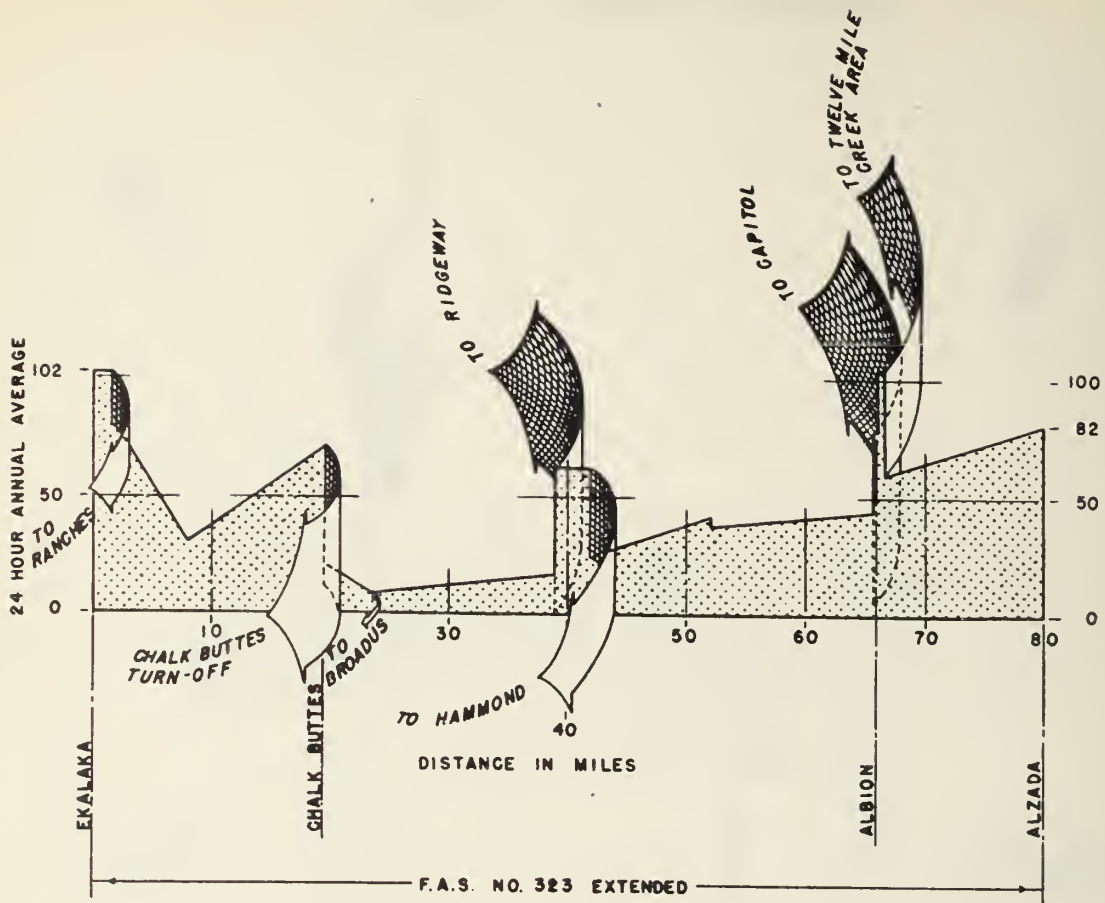
As another example, note the arrow at mile 35.0 indicating the Chalk Buttes turn-off. This is a right turn because the arrow points toward us as we read the profile. The volume of traffic on the Chalk Buttes road at the turn-off is measured vertically at the base of the arrow-head - there is no break in the traffic profile at this point. This situation indicates that traffic on the Chalk Buttes road is evenly distributed on Routing "A", that is, half of this traffic has origin-destination north of the junction and half south of the junction. (Continued on page 12)

TRAFFIC PROFILES EKALAKA-ALZADA, 1960



TRAFFIC PROFILES EKALAKA-ALZADA, 1960





Now let us move to the indicated Alzada turn-off at mile 48.5 and find a volume of 8 in full relief on the indicator arrow leaving a volume of 6 "covered" by the profile. Half of this traffic would have origin-destination north of junction and half south. The total volume on the Alzada turnoff at the junction would be 14 of which 11, ($8 \div 3$) had origin-destination north of the junction and 3 south of the junction.

It is to be noted how the traffic is concentrated along route C, which, as we have previously shown in the SUMMARY OF FINDINGS, is the preferred secondary routing between Ekalaka and Alzada.

IV. ECONOMIC ANALYSES

A. EKALAKA-ALZADA, Primary 28.0 miles and Secondary 66.0 miles, via Sykes Bridge, Ridgeway and Hammond.

1. EKALAKA-SYKES BRIDGE; Oiled Surface 18.5 miles.

a. Annual Cost Calculations

It is assumed that this section of the routing will be built to the standard shown on the upper half of the typical section set forth on page iv of the prefatory assembly, this in keeping with estimated traffic volumes as developed in sub-paragraph 1,b of this sub-section. Costs as developed hereinafter are based on estimated prices prepared by Messrs. P.G. Poore, of the Montana Highway Department and M.J. Wilcomb, of the Public Roads Administration in the course of a field reconnaissance in August 1945.

Construction "experience" in the Ekalaka - Alzada area is shown on page. 14.

Drawing on these data and making due allowance for a probable increase in unit prices in the post war period we find costs as follows:

Re-grading, 9.5 miles @ \$1,500 per mile..... \$14,250

Assuming that there will be re-shouldering operations preparatory to gravel and oil surfacing.

Grading, 9 miles @ \$4,000 per mile..... \$36,000

As per estimate prepared in the course of the field reconnaissance.

Gravel Base and Surfacing, 18.5 miles @ \$3,500 per mile..... \$64,750

Assuming costs similar to those experienced in the 1934-1940 construction near Ekalaka.

Major Drainage Structures, Bridges

1 steel, 100 feet @ \$150 per lineal foot..... \$15,000
1 timber, 60 feet @ \$100 per lineal foot..... \$6,000

As per costs estimated during the course of the field reconnaissance.

Minor Drainage Structures, 9 miles @ \$800 per mile..... \$7,200

Assuming costs considerably less than those experienced in the 1934-40 construction by reason of the arid region traversed.

Oil Surfacing, 18.5 miles @ \$2,000 per mile..... \$37,000

It is assumed that costs for this part of the construction will be comparatively high due to long haul and difficult circumstances attaching to oil surfacing in the Carter County area.

Rights-of-Way, 9.0 miles @ \$500 per mile..... \$4,500

Assuming costs comparable to those experienced during the 1934-1940 construction.

Engineering and Administration

Re-grade, gravel, and oil, 9.0 miles @ \$1,000 per mile. \$9,000
Re-gravel and oil, 9.5 miles @ \$600 per mile..... \$5,700
Bridges, 5% of \$21,000..... \$1,050

BASIC CONSTRUCTION COSTS
EKALAKA, ALZADA & VICINITY
ALZADA-BROADUS, FEDERAL-AID PRIMARY

Project:Const- No.	Year	Length (Miles)	Grading	Drainage Major Struct- ures	Minor Struct- ures	Gravel Base & Surface	Oil Surfac- ing	Engin- eering	Right of Way	Admin- istra- tion
262B	1937	6.9	\$ 21,132	\$ 4,021	\$ 46,452	\$ 7,248	\$ 2,319	\$ 392	\$ 88	
262B	1937	0.03	\$ 7,367							
262B	1937	9.15	\$ 27,954	\$ 5,319	\$ 60,447	\$ 9,162	\$ 3,067	\$ 411	\$ 4,487	\$ 172
262B	1930	9.15	\$ 5,647							
262B	1930	0.06	\$ 15,654							
262B	1930	6.9	\$ 4,226							
262B	1933	31.45	\$ 84,106	\$ 19,183			\$ 307	\$ 8,772	\$ 15,337	\$ 1,777
262C	1933	0.05	\$ 8,481				\$ 697			\$ 128
262C	1933	0.03	\$ 11,350				\$ 933			\$ 171
262C	1933	0.04	\$ 10,818				\$ 889			\$ 163
262C	1935	8.70			\$ 15,804		\$ 948			\$ 536
262C	1937	31.45			\$ 215,687	\$ 36,427	\$ 8,860			\$ 260,974
Total Costs	47.5		\$ 143,065	\$ 53,670	\$ 28,523	\$ 338,390	\$ 52,837	\$ 27,595	\$ 19,824	\$ 3,035
Modern Averages	47.5		\$ 2,804	\$ 1,130	\$ 600	\$ 7,124	\$ 1,112	\$ 581		
Modern Averages	31.45		\$ 2,674	\$ 975	\$ 610	\$ 7,361	\$ 1,158	\$ 671	\$ 488	\$ 88
SECONDARY AND OFF SYSTEM CONSTRUCTION, EKALAKA SOUTHEAST										
347A	1940	0.2	\$ 596		\$ 627		\$ 102			
347A	1936	2.3	\$ 19,914	\$ 5,409	\$ 11,524		\$ 2,483		\$ 902	\$ 653
347B	1940	2.5	\$ 31,529	\$ 4,342	\$ 8,606		\$ 3,714			
318	1940	0.1	\$ 153		\$ 329		\$ 40			
318	1934	4.8	\$ 12,864	\$ 3,341	\$ 12,137		\$ 2,586			\$ 396
318	1934	0.01	\$ 1,992				\$ 182			\$ 26
Total Costs	9.6		\$ 65,056	\$ 13,092	\$ 33,223		\$ 9,107		\$ 902	\$ 1,075
Averages	9.6		\$ 6,777	\$ 1,364	\$ 3,461		\$ 949			\$ 198
Averages	2.3		\$ 8,658	\$ 2,352	\$ 5,010		\$ 1,080		\$ 392	\$ 284

Sub-total..... \$200,450

✓ 10% for contingencies..... \$20,045

Total estimated construction costs, 18.5 miles..... \$220,495

It is believed that traffic will demand and require roads of higher standard as time goes on to thus require a greater outlay on reconstruction. Interest charges should be assigned in recognition of this feature - in other words, the road "as built" should lay up a reserve to meet probable increased construction costs in future. Accordingly the construction costs set forth herebefore have been assigned an interest charge of $2\frac{1}{2}\%$ to be amortized in 20 years. This time period is deemed significant of the service life of the proposed improvement.

From data at hand and in consideration of various statistics ascertained in the course of the Highway Planning Survey, we will assign a maintenance charge of \$100 per mile per year.

The above data along with figures setting forth the annual capital cost which comprehends the application of interest charges, are set forth herebelow.

ANNUAL COST CALCULATIONS

Location of project	Montana	County	Carter
Description of project	Ekalaka - Sykes Bridge		
Highway number	FAS No. 323	Highway system	FA Secondary
Length	18.5 miles	Date of analysis	March 1946

Item	CAPITAL COSTS			Annual Capital Cost
	Net Cost	Interest Rate	Amort. Period	
Rights of way, easements, etc.	\$ 4,500	$2\frac{1}{2}\%$	20 yrs.	\$ 288
Clearing, grading, etc.	50,250	"	"	3,221
Pavements and Surfacing:				
Type Gravel, Base & Surface	64,750	"	"	4,150
Type Oil Surfacing	37,000	"	"	2,372
Structures:				
Type Major, Steel	15,000	"	"	962
Type Major, Tr. Tbr.	6,000	"	"	384
Type Minor,	7,200	"	"	462
Engineering & Administration.....	15,750	"	"	1,010
✓ 10% for contingencies.....	20,045	"	"	1,285
1. Total annual capital cost.....				\$ 14,134

MAINTENANCE COSTS

2. Total annual maintenance cost	18.5 miles @ \$100	\$ 1,850
3. TOTAL ANNUAL COSTS (1 ✓ 2)		\$ 15,984

b. Average daily traffic, 1960

As brought out in Section III of this report there are several elements of traffic comprising the whole of traffic for each route proposed for analysis. All of which can be classified under the general heads of

"Local Traffic" and "Diverted Traffic."

(1) Local Traffic

Those data set forth in Section III in reference to traffic volume apply as an average for the full length of each of the several listed routes. In a situation such as this we know that there are very few "through" trips; that is to say, trips which contemplate origin-destination beyond the north and south terminals, Ekalaka and Alzada respectively. We know also that each route as proposed for construction will not scrape the door step of each and every resident of the interior areas of Carter County - some few persons will have to travel over lesser roads to gain access to the routing as built. The road problem in Carter County then resolves into a proposition of trying to deliver a maximum of service by the construction of one key road along the north-south axis of the county and then designating certain "county-feeder" roads for improvement which will thereby afford access to the key road to allow year round travel for the residents of the region. For this reason traffic and road use will be analyzed with due consideration for approach mileage "old" and "new". By so presenting the picture we will have a general over all portrayal of travel habits along the routing both "before" and "after" and better still we will be able to show the composite affect of the new construction in terms of shortened travel distance and in improved riding surface. As an example let us take a rancher living 8 miles northwest of Ridgeway on the county road leading to Chalk Buttes. It is reasonably safe to say that any trip he might presently make to or through Ekalaka will involve travel through Chalk Buttes, over some 35 miles of the existing county road plus one mile of approach or access road. Next let us say that by reason of the construction proposed in this particular analysis he will so change his travel habits as to avail himself of 18.5 miles of travel on an oiled surface - the approach mileage will have increased by the distance between the ranch and Sykes Bridge, 26 miles, but the total mileage involved in the trip will have increased by only 9.5 miles. Meanwhile, he will, as shown in other parts of this analysis save time and operating expenses - this to illustrate the effect of road construction some 27.5 miles removed from the rancher-road user set forth in the example.

The method of analysis used in this report in reference to traffic volume and travel-distance represents a departure from orthodox methods in that the resultant traffic volume is far in excess of that shown on the charts Section III, while the "new" travel distance along the length of the routing under study is less than that shown to be the true length of the improvement. This by reason of the fact that we consider entry traffic along with that traffic which originates in Ekalaka or Alzada. By the usual methods of computation we find the average traffic value of the road "as built" in 1960 from Ekalaka to Sykes Bridge, a distance of 18.5 miles, to be 104 vehicles per day per mile. By the method discussed herebefore in which we treat with 174 vehicles traveling over 11.1 miles of "new" roadway we arrive at a similar result.

Here are the data in reference to volume and travel-distance "old" and "new" for that element of traffic which we will label tentatively as "Existing Traffic." (See page 17)

Origin - Destination	EXISTING FACILITIES (Miles)				NEW FACILITIES (Miles)						
	PTW	APPROACH	TOTAL TRAVEL DISTANCE	NEW APPROACH	NEW TRAVEL DISTANCE	Total	Oil:Unimp	Oil:Unimp	Total		
	ADT :Gravel:Unimp:	Oil:Unimp:	Oil:Gravel:Unimp:	Total:	Oil:	Oil:Unimp:	Oil:Unimp:	Oil:Unimp:	Total		
Ekalaka-Belltower Road	147.2	7.65	2.85	6.9	7.65	9.75	17.4	10.1	6.9	17.0	
-Chalk Buttes Road	3.0	9.5	28.5	16.0	9.5	44.5	54.0	18.5	34.0	52.5	
-Albion Road	7.6	9.5	31.5	20.0	9.5	51.5	61.0	18.5	41.0	59.5	
-Ranches	4.4	9.5	35.5	2.0	9.5	37.5	47.0	18.5	27.0	45.5	
-School Road	3.2	9.5	39.5	3.0	9.5	42.5	52.0	18.5	32.0	50.5	
-Alzada Road	2.0	9.5	42.5	20.0	9.5	62.5	72.0	18.5	52.0	70.5	
-Ranches	0.2	9.5	56.5	1.0	9.5	57.5	67.0	18.5	47.0	65.5	
-Piniele Road	0.2	9.5	59.5	2.0	9.5	61.5	71.0	18.5	51.0	69.5	
-Broadus Road	1.0	9.5	62.5	28.0	9.5	62.5	100.0	18.5	52.0	98.5	
-Alzada	1.2	9.5	62.5	29.0	9.5	62.5	101.0	18.5	52.0	99.5	
Ekalaka-Through to Alzada	170.0	7.9	7.5	0.35	7.9	15.0	23.25	11.25	0.35	11.1	22.7
Ranch Entry-Belltower Road	2.8			13.5		19.5	19.5	5.25	13.5	18.75	
-Albion Road	0.4			25.0		54.0	54.0	7.0	46.0	53.0	
-Ranches	0.4			7.0		40.0	40.0	7.0	32.0	39.0	
-School Road	0.2			8.0		45.0	45.0	7.0	37.0	44.0	
-Alzada	0.2			5.0	29.0	65.0	94.0	7.0	57.0	93.0	
Ranches-Through to Alzada	4.0			1.45	13.3	28.55	30.0	5.8	21.95	29.2	
Total Traffic	174.0	7.7	7.65	0.4	7.7	15.3	23.4	11.1	0.4	11.35	22.85

On observation of the tabulation we find that over-all travel-distance is decreased by 0.55 miles, (23.4 - 22.85), on completion of construction of the Ekalaka-Sykes Bridge section of the total routing.

It is to be noted that this decrease is effective with respect to all traffic which might have occasion to travel the total length of the routing or the cited portion thereof.

Given a time that this section of the routing is improved there will be some few local or interior diversions to the new route. This route being of such extent and meandering as it does by way of Hammond there will not be a great deal of such diversion. By reference to tabulations at hand we find possibilities of interior diversions as follows:- (See tabulation "INTERIOR DIVERSION TO THE EKALAKA-SYKES BRIDGE SECTION OF THE EKALAKA-ALZADA ROUTING, 1960", page 19)

These data when combined with those data pertaining to "Existing Traffic" give us composite traffic and travel-distance with results as shown on the tabulation. "LOCAL TRAFFIC, ETC.", page 19.

To thus allow us to arrive at a summation of all local traffic having occasion to use this section of the routing.

From various study points located throughout Carter County we find the traffic distributed to vehicle type as follows:

DISTRIBUTION OF LOCAL TRAFFIC	
BY VEHICLE TYPES	
: Local Passenger Cars	47.0%
: Out-of-State Passenger Cars	2.0%
: All Passenger Cars	49.0%
: Light Trucks, $1\frac{1}{2}$ ton rated capy. or less	39.7%
: Medium Trucks, more than $1\frac{1}{2}$ ton and less than 5 ton rated capy.	4.0%
: Heavy Trucks, 5 ton rated capy. and more than 5 ton capy.	2.2%
: Tractor-truck and Semi-trailer Combinations	2.5%
: Truck and Full Trailer Combinations	1.2%
: Busses, School and Others	1.4%
: All trucks and Busses	51.0%
: All Traffic	100.0%

(2) Diverted Traffic

As set forth in Section III this element of traffic will be treated as a separate entity. We have said previously that 4 vehicles per day currently traveling from Alzada to Glendive by way of Miles City will divert to the Ekalaka - Hammond - Alzada routing when built, along with two vehicles which now travel from and to Ekalaka by way of Alzada, Bellefourche, South Dakota, Bowman, North Dakota and Baker Montana.

Data in reference to this category of traffic are as shown on the tabulation, page 20.

The tabulation sets forth travel conditions before and after construction of the whole of the Ekalaka - Hammond - Alzada routing. Pertinent material as it relates to income, time savings, and mileage element savings (continued on page 20)

INTERIOR DIVERSION TO THE EKALAKA-SYKES
BRIDGE SECTION OF THE EKALAKA-ALZADA ROUTING, 1960

Origin - Destination	EXISTING FACILITIES (Miles)			NEW FACILITIES (Miles)		
	PTW	APPROACH	TOTAL TRAVEL DISTANCE	PTW	APPROACH	TOTAL TRAVEL DISTANCE
	ADT:Gravel:Unimp:	Oil:Unimp:	Oil:Gravel:Unimp:	Total:	Oil:Oil:	Unimp:Oil:Unimp: Total
Ekalaka-Ranches	: 0.4:	: 35.0 :	: 1.0 :	: 36.0 :	: 36.0 :	: 18.5: : 27.0:18.5: 27.0: 45.5
-Ridgeway Road	: 0.6:	: 43.0 :	: 19.0 :	: 62.0 :	: 62.0 :	: 18.5: : 37.0:18.5: 37.0: 55.5
-Albion Road	: 0.2:	: 46.0 :	: 20.0 :	: 66.0 :	: 66.0 :	: 18.5: : 41.0:18.5: 41.0: 59.5
-Ranches	: 0.2:	: 50.0 :	: 2.0 :	: 52.0 :	: 52.0 :	: 18.5: : 27.0:18.5: 27.0: 45.5
-School Road	: 0.2:	: 54.0 :	: 3.0 :	: 57.0 :	: 57.0 :	: 18.5: : 32.0:18.5: 32.0: 50.5
-Alzada	: 0.2:	: 82.5 :	: 7.0 :	: 89.5 :	: 82.5 :	: 18.5: 7.0 : 57.5:25.5: 57.5: 83.0
Total Diversion	: 1.8:	: 47.95:0.8 :	: 9.35:0.8 :	: 57.3 :	: 58.1 :	: 18.5:0.8 : 35.85:19.3: 35.85: 55.15
Effective Diversion	: 3.0:	: 27.85:0.45:	: 5.4 :	: 0.45:	: 33.25:33.7 :	: 11.1:0.45: 21.5:11.55: 21.5: 33.05

LOCAL TRAFFIC WITH TRAVEL-DISTANCE DATA AS OF COMPLETION
OF THE EKALAKA-SYKES BRIDGE SECTION OF THE
EKALAKA-ALZADA ROUTING

Traffic Classification	EXISTING FACILITIES (Miles)			NEW FACILITIES (Miles)		
	PTW	APPROACH	TOTAL TRAVEL DISTANCE	PTW	APPROACH	TOTAL TRAVEL DISTANCE
	ADT:Gravel:Unimp:	Oil:Unimp:	Oil:Gravel:Unimp:	Total:	Oil:Oil:	Unimp:Oil:Unimp: Total
Existing Traffic	: 174:	: 7.65:	: 0.4:	: 7.7 :	: 15.3 :	: 23.4 :11.1: 0.4:11.35:11.5:11.35: 22.85
Diverted Traffic	: 3:	: 27.85:	: 0.45:	: 5.4 :	: 0.45:	: 33.25: 33.7 :11.1: 0.45:21.5 :11.55:21.5 : 33.05
All Local Traffic	: 177:	: 7.55 :	: 8.0 :	: 0.4:	: 7.55 :	: 15.6 : 23.55:11.1: 0.4:11.5 :11.5:11.5 : 23.0

for each section of the whole route length 94 miles, will be ascribed to each component section in the ratio that the section bears to the whole of the distance between Ekalaka and Alzada. In this first analysis this distance, Ekalaka to Sykes Bridge, comprises 19.7% of the whole route distance.

DIVERTED TRAFFIC, 1960

TRAVEL ROUTES	EXISTING FACILITIES (Miles)			
	ADT	SURFACE	SURFACE	DISTANCE
Alzada-Miles City-Glendive	4	214.0		214.0
Alzada-Bellefourche-Bowman-Baker-Ekalaka	2	51.0	203.0	254.0
Composite Present Travelled Way	6	160.0	67.0	227.0

TRAVEL ROUTES	1960 FACILITIES (Miles)			
	ADT	SURFACE	SURFACE	DISTANCE
Alzada-Ekalaka-Baker-Wibaux-Glendive	4	159.5	47.5	207.0
Alzada-Ekalaka	2	46.5	47.5	94.0
Composite on Completion Alzada-Ekalaka Route	6	122.0	47.5	169.5

c. Annual Revenues

To arrive at an estimate of annual revenues the traffic data were resolved into vehicle miles and then into ton miles. These data were then extended on the basis of unit net revenues per ton mile to arrive at an estimate of the total annual income. Unit net revenues rates derive from a general study conducted by this department. Average gross ton figures for each class of vehicles were also ascertained during the course of research work by the Planning Survey. It is to be noted that this income accrues by virtue of the Gasoline License Tax Levy and that it is effective for the full length of the proposed improvement, that is, from Ekalaka to Sykes Bridge, a distance of 18.5 miles. Tabulation as shown on the following page.

HIGHWAY PROJECT ANALYSIS

Traffic Income

Location of Project Montana Description of project Ekalaka - Sykes Bridge County Carter
 Highway FAS #323 Highway System FA Secondary Length 18.5 miles Date of analysis March 1946

Traffic Type	Average Annual Traffic			Average Annual			Unit Net			Total Annual		
	Local Traffic			Diverted Traffic			Road Use During			Revenues		
	Vehicles			Vehicles			Ton			Life of project:Per Ton.Mi:		
	: 1/	: 2/	: Miles	: 1/	: 2/	: Miles	: 1/	: 2/	: Miles	: 1/	: 2/	: Miles
Passenger Cars - Montana	: 30,295	: 504,417	:	: 1,588	:	:	: 44,093	:	:	: 548,510	:	:
Passenger Cars - Foreign	: 1,460	: 24,309	:	: 273	:	:	: 7,575	:	:	: 31,884	:	:
Total passenger cars	: 31,755	: 528,726	:	: 1,861	:	:	: 51,668	:	:	: 580,394	:	:
Trucks, light	: 25,550	: 927,383	:	: 176	:	:	: 10,627	:	:	: 938,010	:	:
Trucks, medium	: 2,591	: 197,869	:	: 43	:	:	: 5,550	:	:	: 203,419	:	:
Trucks, heavy	: 1,424	: 176,246	:	: 6	:	:	: 1,248	:	:	: 177,494	:	:
Trucks, semi-trailer	: 1,606	: 263,125	:	: 43	:	:	: 11,877	:	:	: 275,002	:	:
Trucks, full-trailer	: 767	: 194,883	:	: 17	:	:	: 6,993	:	:	: 201,876	:	:
Busses	: 912	: 91,109	:	: 44	:	:	: 7,242	:	:	: 98,351	:	:
Total trucks & busses	: 32,850	: 1,850,615	:	: 329	:	:	: 43,537	:	:	: 1,894,152	:	:
Total all vehicles	: 64,605	: 2,379,341	:	: 2,190	:	:	: 95,205	:	:	: 2,474,546	:	:

Total Annual Income \$5,966

1/ Average daily traffic each component as developed in sub-section b, page 18, multiplied by 365, the number of days in the year.

2/ Annual vehicles multiplied by the average gross weight of each component of traffic times the length of the "new" construction, 11.1 miles. Average gross weights are as shown:

Passenger Cars.....	1.50 tons
Trucks, light.....	3.27 tons
Trucks, medium.....	6.88 tons
Trucks, heavy.....	11.15 tons
Trac. Truck-Semi Trailer Combinations.....	14.76 tons
Truck and Full Trailer Combinations.....	22.89 tons
Busses.....	9.00 tons

d. Time Element Savings

Time element savings accrue to traffic as a result of surface and alignment improvements and because of shortened travel-distance. Here the traffic will be enabled to travel at accelerated speeds due to surface and alignment improvements along with a decrease in over all travel-distance. This latter feature of the new construction applies in so far as decrease in travel-distance to the diverted traffic is concerned. Composite time element savings are tabulated hereinafter. The "new" speed rates originate with data published in the Oregon Technical Bulletin; the old speed rates coincide with information shown in the Technical Bulletin.

HIGHWAY PROJECT ANALYSIS

Time Element Savings

Location of project	MONTANA	County	CARTER
Description of project	EKALAKA -SYKES BRIDGE		
Highway number	FAS No. 323	Highway System	FA SECONDARY
Length	18.5 miles	Date of analysis	MARCH 1946

Annual Traffic Volume	Local Traffic		Diverted Traffic	
	New	Old	New	Old
Private Passenger cars (per year)	31,755		1,861	
Trucks, light (per year).....	25,550		176	
Trucks, medium (per year).....	2,591		43	
1/Trucks, heavy (per year).....	4,709		110	
Totals.....	64,605		2,190	
Private Passenger Cars				
2/Average speed (miles per hour)...	36.5	32.8	41.6	41.5
3/Distance (Miles).....	23.0	23.55	169.5	227.0
Time (hours per trip).....	0.630	0.718	4.075	5.469
Time savings per vehicle.....	0.088		1.394	
Value of savings (\$/vehicle-hour)	\$0.60		\$0.60	
Annual traffic volume.....	31,755		1,861	
Value of time savings.....			\$1,557	
Totals.....	\$1,677		\$307.19.7%	

Time Element Savings (cont.)

Trucks, Light	New	Old	New	Old
Average speed (miles per hour)...	33.5	29.8	38.6	38.5
Distance (miles).....	23.0	23.55	169.5	227.0
Time (hours per trip).....	0.686	0.790	4.391	5.896
Time savings per vehicle.....	0.104		1.505	
Value of savings (\$/vehicle-hour)	\$0.86		\$0.86	
Annual traffic volume.....	25,550		176	
Value of time savings.....			\$228	
Totals.....	\$ 2,285		\$45, 19.7%	
Trucks, Medium				
Average speed (miles per hour)...	29.5	25.8	34.6	34.5
Distance (miles).....	23.0	23.55	169.5	227.0
Time (hours per trip).....	0.780	9.13	4.899	6.580
Time savings per vehicle.....	0.133		1.681	
Value of savings (\$/vehicle-hour)	\$1.17		\$1.17	
Annual traffic volume.....	2,591		43	
Value of time savings.....			\$85	
Totals.....	\$403		\$17, 19.7%	
Trucks, Heavy				
Average speed (miles per hour)...	26.5	22.8	31.6	31.5
Distance (miles).....	23.0	23.55	169.5	227.0
Time (hours per trip).....	0.868	1.033	5.364	7.206
Time savings per vehicle.....	0.165		1.842	
Value of savings (\$/vehicle-hour)	\$1.47		\$1.47	
Annual traffic volume.....	4,709		110	
Value of time savings.....			\$298	
Totals.....	\$1,142		\$59, 19.7%	
Total..each category.....	\$5,507		\$428	
TOTAL ANNUAL TIME ELEMENT SAVINGS			\$5,935	

1/ Busses and Truck and Trailer Combinations included with Truck, heavy.

2/ Average speed (miles per hour) computed for the total travel-distance both "old" and "new".

3/ Distance (in miles) from those distances set forth on the tabulation of traffic and travel-distance, page 17.

e. Mileage Element Savings

These savings accrue to traffic as a circumstance of generally improved riding surface and a decrease in travel distance. These factors operate to decrease wear and tear on engines; they make a gallon of gas stretch farther. The estimated savings are tabulated hereinafter. Procedures based on methods in use by the Oregon State Highway Department, are explained in notes set forth thus 1/, 2/, etc.

HIGHWAY PROJECT ANALYSIS

Mileage Element Savings

Location of project	MONTANA	County	CARTER
Description of Project	EKALAKA * SYKES BRIDGE		
Highway number	FAS No. 323	Highway system	FA SECONDARY
Length	18.5 Miles	Date of Analysis	MARCH 1946

Distance	Local Traffic		Diverted Traffic	
	New	Old	New	Old
Length (miles).....	1/ 23.0	23.55	169.5	227.0
Distance savings (miles).....	2/ 0.55		57.5	
Average annual traffic (tons).....	3/ 214,355		5,146	
Annual traffic saving (ton-mi.)....	4/ 117,895		295,895	
Cost (\$/ton-mile).....	\$0.0178		\$0.0196	
Annual savings.....			\$5,800	
Total.....	\$ 2,099		\$1,143, 19.7%	

Surface 5/

Roadway surface type.....	0.155	0.245	0.077	0.075
Saving coefficient.....	0.09		0.002	
Aver. annual traffic (ton-mi.).....	5,048,060		1,168,142	
Saving (\$/ton-mile).....	\$0.0016		0.00004	
Annual Saving.....			\$47	
Total.....	\$ 8,077		\$9 , 19.7%	

Alignment 6/

Curvature rating.....	5.0	3.4	10.0	9.4
Points improvement.....	1.6		0.6	
Saving (point-ton-miles).....	8,076,896		700,885	
Saving (\$/point-ton-mile).....	\$0.0001		\$0.0001	
Annual saving.....			\$70	
Total.....	\$ 808		\$14 , 19.7%	
Total..Each Category.....	\$ 10,984		\$ 1,166	

TOTAL ANNUAL MILEAGE ELEMENT SAVINGS.....\$ 12,150

Local Traffic

1/ Length (miles); refer to tabulation page 19 and note total mileage set forth under "EXISTING FACILITIES" and "NEW FACILITIES" which apply in the computation of mileage element benefits.

2/ Average annual traffic (tons); multiply the average daily traffic by 365 by the average gross weight for each component of traffic.

3/ Multiply the average annual traffic in tons by the distance saving in miles.

4/ Cost (\$/ton mile).

Percentage of trucks (see tabulation page 18) is 51%.

Average gross weight of trucks (from detailed computations at hand in this department) is 10,150 lbs. From Figure 113 of the Oregon Technical Bulletin we find that the truck mileage operating cost for a truck of gross weight 10,150 pounds is \$0.0151 per ton mile. Similar costs for passenger cars is \$0.0207 per ton mile. Combining these costs in the proportion manifest in this particular category of traffic we have an operating cost of \$0.0178 per ton mile. See below:

Passenger cars (49%) = $0.49 \times \$0.0207 = \0.0101

Trucks (51%) = $0.51 \times \$0.0151 = \0.0077

Combined costs per ton mile... \$0.0178

Cost (\$/ton mile) time the Annual Traffic Savings (ton miles) equals the total saving.

5/ Surface

It is proposed that the "new" work comprise bituminous surfacing with a coefficient rating of 0.03. (See Oregon Technical Bulletin for discussion of coefficients). The composite coefficient rating of the travel-distance on completion of the proposed improvement would be computed as follows:

Oil Surfacing, 11.5 miles; 50%, $0.50 \times 0.03 = 0.015$

Unimproved, 11.5 miles; 50%, $0.50 \times 0.28 = 0.14$

Composite Surface Coefficient.... 0.155

The composite surface coefficient of the travel-distance interval "as is" is as follows:

Oil Surfacing, 0.4 miles; 1.7%, $0.017 \times 0.03 = 0.0005$

Gravel Surfacing, 7.55 miles; 32.1%, $0.321 \times 0.19 = 0.0600$

Unimproved, 15.6 miles; 66.2%, $0.662 \times 0.28 = 0.1850$

Composite Surface Coefficient..... 0.2455

The latter coefficient rating less the "new" coefficient gives us the saving coefficient; this figure time the cost (\$/ton mile) gives us the saving (\$/ton mile) and this figure times the average annual traffic (ton miles) allows us to arrive at the total saving.

6/ Alignment

In reference to the curvature rating "as built" assume that 11.5 miles, 50% would have an alignment rating of 10 and that the remaining interval would have a zero rating - the composite rating would then be 5. With respect to the travel-distance routing "as is" there would be 7.95 miles bearing a rating of 10 and 15.6 miles bearing a rating of zero - the composite rating would be 3.4. The "new" rating less the "old" rating will give us the "Points improvement, 1.6 in this case. This figure times the ton miles will give us the "Saving (point-ton-miles)." The "Saving (\$/point-ton-mile)," \$0.0001 is a figure deriving from the Oregon Technical Bulletin and was determined in the course of research by the Oregon Highway Department. This saving rate times the saving (point-ton-mile) gives us the total annual alignment saving.

7/ All data pertaining to mileage element savings in reference to the "Diverted Traffic" was computed as though the whole routing were completed in accord with procedures illustrated for the "Local Traffic" discussion. Since the Ekalaka-Sykes Bridge interval comprises 19.7% of the length of the total routing it was deemed fair and impartial in this case to allow credit for mileage element savings in that ratio for this piece of construction.

f. Traffic Benefits

This tabulation involves an allocation of benefits, non-fuel function and fuel function, in accord with the proportions advanced by the Oregon Highway Department. See the Technical Bulletin.

HIGHWAY PROJECT ANALYSIS

Traffic Benefits

Location of project	MONTANA	County	CARTER
Description of project	EKALAKA - SYKES BRIDGE		
Highway number	FAS no. 323	Highway system	FA SECONDARY
Length	18.5 miles	Date of analysis	MARCH 1946

Mileage Element Factors

Item			Fuel Function	Non-fuel Function
Distance savings	\$3,242	38%	\$ 1,232	\$ 2,010
Roadway surface savings	8,086	43%	3,477	4,609
Alignment savings	822	50%	411	411
Total Mileage Savings	\$12,150		\$ 5,120	\$ 7,030

Time Element Savings

Type of Traffic	Annual Value of Time Savings
Passenger cars	\$ 1,984
Trucks, light	2,330
Trucks, medium	420
Trucks, heavy	1,201
Busses	
Total Time Savings	\$ 5,935

Recapitulation of Annual Benefits

Total Fuel Function Benefits	\$ 5,120
Non-fuel function benefits	(Mileage element factors \$ 7,030 (Time element factors \$ 5,935)
Total Non-fuel Function Benefits	\$ 12,965
TOTAL ANNUAL BENEFITS	\$ 18,085

g. Derivation of Quotients

Now to marshall such factual data as we have assembled heretofore. Tabulation is shown on the following page.

HIGHWAY PROJECT ANALYSIS

Location of project	MONTANA	County	CARTER
Description of project	EKALAKA - SYKES BRIDGE		
Highway number	FAS No. 323	Highway system	FA SECONDARY
Length	18.5 Miles	Date of analysis	MARCH 1946

$$\begin{aligned}
 I_{ar} &= \$ 5,966 & K_1 &= 1.00 & 1/ \\
 C_a &= \$ 15,984 & K_2 &= 445/5,120 = 0.085 & 2/ \\
 B_n &= \$ 12,965 & K_3 &= 0.05/0.20 = 0.25 & 3/ \\
 B_f &= \$ 5,120 & K_2 K_3 &= 0.085 \times 0.25 = 0.02 & 4/ \\
 K_1 C_a &= \$ & 1 - K_2 K_3 &= 1.00 - 0.02 = 0.98 \\
 Q_s = I_{ar}/K_1 C_a &= 5,966/15,984 = 0.375 \\
 Q_{Bn} = B_n/K_1 C_a &= 12,965/15,984 = 0.81 \\
 Q_{Bf} = B_f/K_1 C_a &= 5,120/15,984 = 0.32 \\
 Q'_s = Q_s - K_2 K_3 Q_{Bf} &= 0.375 - 0.02 \times 0.32 = 0.375 - 0.0064 = 0.3686 \\
 Q_c = 0.707 (Q_s/Q_{Bn} - Q_{Bf})(1 - K_2 K_3) &= 0.707 (0.375/0.81 - 0.32 \times 0.98) \\
 &= 0.707 (0.375/0.81 - 0.3115) \\
 &= 0.707 \times 1.50 \\
 &= 1.06
 \end{aligned}$$

1/ The constant K_1 represents the Pro Rata cost chargeable to Road User funds, the Gasoline License Tax Levy in this case.

2/ The constant K_2 represents the proportion of the total fuel savings which derives from the diverted traffic. By reference to the tabulation of Mileage Element Savings and extending on the basis of the distribution factors shown on the tabulation of Traffic Benefits, we find that the fuel function benefits accruing to the diverted traffic are \$455.00. This figure divided by the total of the fuel function benefits, B_f gives the resultant 0.085.

3/ The constant K_3 represents the ratio of fuel tax to the total cost of fuel.

4/ By combining the constant $K_2 K_3$ we arrive at a measure or percentage factor showing the relative decrease in revenues on adjoining highway systems which occurs by reason of diverting traffic to the new routing.

5/ Q_s represents the solvency quotient - if it were 1.00, annual revenues would balance estimated annual expenditures. In this case the solvency quotient is 0.375. Estimated revenues do not balance estimated expenditures by an appreciable sum - at first glance we would say the routing is not feasible economically speaking. But the highway picture involves a whole lot more than mere comparison of income and expenditures. There are benefits which accrue to the road user which have an important bearing in the matter. These benefits expressed as quotients hereinafter, when added to the solvency quotient express a gross financial solvency which in this case moves the contemplated construction onto the profit side of the ledger.

6/ and 7/ Q_{B_n} Q_{B_f} represent the benefit quotients, non-fuel and fuel respectively. Note that these benefits, in this case, are 1.13 times the annual estimated capital costs.

8/ Q'_s is a corrected solvency quotient - the Ekalaka-Sykes Bridge section if built, and thus entered in the Montana highway picture will act to decrease the revenues of those routes from which traffic is diverted. Q'_s represents the net solvency of the proposed improvement in respect to other parts of the highway system.

9/ Q_c represents the composite quotient. Heretofore we have determined financial solvencies, now we compare benefits with revenues to determine the feasibility or desirability of the route. In this particular case the benefits are in excess of revenues, to indicate that the road user will not only accumulate funds (as listed the tabulation of Traffic Benefits) to pay his taxes, but have some "little profit" left over. By virtue of the composite solvency 1.06, this section of the routing from Ekalaka to Sykes Bridge is justified from an economic stand point.

2. EKALAKA-RIDGEWAY; Oiled Surface 18.5 miles, Gravel Surface 16.5 miles, total travel-distance 35.0 miles.

a. Annual Cost Calculations

When we consider this proposal for construction from Ekalaka over Sykes Bridge and thence to Ridgeway, we find traffic volume over the latter mentioned interval to be less than 100 vehicles per day per mile, hence this section will be brought to gravel surface standards with a commensurate decrease in construction costs per mile. Tabulation of estimated costs is as follows:

Re-grading, 9.5 miles @ \$1,500 per mile.....	\$14,250
Grading, 25.5 miles @ \$4,000 per mile.....	\$102,000
Gravel Base and Surface, 35 miles @ \$3,500 per mile.....	\$122,500
Major Drainage Structures, bridges	
2 Steel, 200 feet @ \$150 per lineal foot.....	\$30,000
11 Timber, 660 feet @ \$100 per lineal foot.....	\$66,000
Minor Drainage Structures, 25.5 miles @ \$800.....	\$20,400

Oiled Surface, 18.5 miles @ \$2,000 per mile..... \$37,000

Rights-of-Way, 9.0 miles @ \$500 per mile..... \$4,500

16.5 miles @ \$400 per mile..... \$6,600

Engineering and Administration

Grading, gravel and oil 9.0 miles @ \$1,000 per mile.... \$9,000

Re-gravel and oil 9.5 miles @ \$600 per mile..... \$5,700

Grade and gravel 16.5 miles @ \$800 per mile..... \$13,200

Bridges, 5% of \$96,000..... \$4,800

Sub-total.....\$435,950

✓ 10% for contingencies..... \$43,595

Total construction charges, 35 miles.....\$479,545

These items along with extensions to arrive at an annual construction capital cost and an estimated annual maintenance cost are listed hereinafter.

ANNUAL COST CALCULATIONS

Location of project	MONTANA	County	CARTER
Description of project	EKALAKA-RIDGEWAY		
Highway number	FAS No. 323	Highway system	FA SECONDARY
Length	35.0 miles	Date of analysis	MARCH 1946

CAPITAL COSTS

Item	Net Cost	Interest Rate	Amort. Period	Annual Capital Cost
Rights of way, easements, etc.	\$ 11,100	2½%	20 yrs.	\$ 712
Clearing, grading, etc.	116,250	"	"	7,452
Pavements and surfacing:				
Type Gravel, Base & Surface	122,500	"	"	7,852
Type Oil Surfacing	37,000	"	"	2,372
Structures:				
Type Major, 2 Steel	30,000	"	"	1,923
Type Major, 11, Timber	66,000	"	"	4,230
Type Minor	20,400	"	"	1,308
Engineering & Administration.....	32,700	"	"	2,096
✓ 10% for contingencies.....	43,595	"	"	2,794
1. Total annual capital cost.....				\$30,739

MAINTENANCE COSTS

2. Total annual maintenance cost 35.0 miles @ \$100.00 \$ 3,500

TOTAL ANNUAL COSTS (1 ✓ 2) \$34,239

b. Average Daily Traffic, 1960

(1) Local Traffic

With the extension of construction to Ridgeway, there is a commensurate increase in the "new" travel-distance along with the possibility of increased interior diversions. Existing traffic which will divert from the EKALAKA-CHALK BUTTES-RIDGEWAY routing will be increased by a small addition of diverted traffic from the EKALAKA-SYKES BRIDGE-CAPITOL-ALBION-ALZADA routing. A summary of the local traffic along with specific information in reference to travel-distance "old" and "new" is as shown on page 31.

(2) Diverted Traffic

In the amount shown in sub-paragraph (2) page 18, with the exception that this traffic is effective over 37.2% of the total length of the routing.

c. Annual Revenues

Annual income accruing to the Ekalaka-Ridgeway section as of 1960, is as set forth on page 32.

d. Time Element Savings

As per tabulation which follows:

HIGHWAY PROJECT ANALYSIS

Location of project		Time Element Savings	
MONTANA		CARTER	
Description of project		EKALAKA-RIDGEWAY	
Highway number	FAS No. 323	Highway system	FA SECONDARY
Length	35.0 Miles	Date of analysis	MARCH 1946
		Local Traffic	Diverted Traffic
		@ 37.2%	
Annual Traffic Volume		New	Old
Private Passenger cars (per year)		39,457	
Trucks, light (per year).....		31,974	
Trucks, medium (per year).....		3,312	
Trucks, heavy (per year).....		5,877	
Totals.....		80,520	
Private Passenger Cars			
Average speed (miles per hour)...		36.3	32.3
Distance (Miles).....		24.3	25.35
Time (hours per trip).....		0.669	0.785
Time savings per vehicle.....		0.116	
Value of savings (\$/vehicle-hour)		\$0.60	
Annual traffic volume.....		39,457	
Totals.....		\$ 2,746	\$579
Trucks, light			
Average speed (miles per hour)...		33.3	29.3
Distance (miles).....		24.3	25.35
Time (hours per trip).....		0.730	0.865
Time savings per vehicle.....		0.135	
Value of savings (\$/vehicle-hour)		\$0.86	
Annual traffic volume.....		31,974	
Totals.....		3,712	\$85

(cont'd on page 33)

LOCAL TRAFFIC WITH TRAVEL-DISTANCE DATA AS OF
COMPLETION OF THE EKALAKA-RIDGEMAY SECTION
OF THE EKALAKA-ALZADA ROUTING

	EXISTING FACILITIES (Miles)				NEW FACILITIES (Miles)			
	PTW	APPROACH	TOTAL TRAVEL DISTANCE	NEW	APPROACH	TOTAL TRAVEL DISTANCE		
TRAFFIC								
CLASSIFIC'N	ADT	GRAVEL:UNIMP:OIL	GRAVEL:UNIMP:TOTAL	OIL:GRAVEL:OIL	UNIMP:OIL	GRAVEL:UNIMP: TOTAL		
Existing								
Traffic	212.0	6.35 : 0.8 : 8.6	18.2:25.35:9.1	3.25	0.8:11.25:9.9	3.25:11.25: 24.4		
Diverted								
Traffic	8.6: 1.1	21.55: 0.15: 3.15	0.15: 1.1	6.15	0.15:10.7 :6.35:	6.15:10.7 : 23.2		
Local								
Traffic	220.6	6.15 :10.05: 0.75:	8.4 : 0.75: 6.15	18.45:25.35:9.0	3.35 : 0.75:11.2	3.35:11.2 : 24.3		

HIGHWAY PROJECT ANALYSIS

Traffic Income

Location of project Montana Description of project Ekelaka - Ridgeway County Carter
 Highway FAS #323 Highway System FA Secondary Length 35.0 miles Date of analysis March 1946

Traffic Type	Average Annual Traffic				Average Annual : Unit Net : Total Annual			
	Local Traffic		Diverted Traffic		:Road Use During:Revenues		:Net Revenue	
	Vehicles	Ton	Vehicles	Ton	:Life of project:Per Ton Mi:			
	Miles		Miles		Ton Mile			
Passenger Cars - Montana	37,850	701,171	1,588	83,413	784,584	\$0.002188	\$1,717	
Passenger Cars - Foreign	1,607	29,764	273	14,331	44,095	0.001799	79	
Total passenger cars	39,457	730,935	1,861	97,744	828,679		\$1,796	
Trucks, light	31,974	1,291,254	176	20,106	1,311,360	0.003248	\$4,259	
Trucks, medium	3,212	272,923	43	10,498	283,421	0.002382	675	
Trucks, heavy	1,789	246,345	6	2,363	248,708	0.001619	403	
Trucks, semi-trailer	2,007	365,844	43	22,467	388,311	0.001543	599	
Trucks, full-trailer	949	268,279	17	13,229	281,508	0.001396	393	
Busses	1,132	125,822	44	13,701	139,523	0.001873	261	
Total trucks & busses	41,063	2,570,467	329	82,364	2,652,831		\$6,590	
Total all vehicles	80,520	3,301,402	2,190	180,108	3,481,510		\$8,386	

Total Annual Income.....\$8,386

	Local Traffic		Diverted Traffic @ 37.2%	
	New	Old	New	Old
<u>Trucks, Medium</u>				
Average speed (miles per hour)...	29.3	25.3		
Distance (miles).....	24.3	25.35		
Time (hours per trip).....	0.829	1.002		
Time savings per vehicle.....	0.173			
Value of savings (\$/vehicle-hour)	\$1.17			
Annual traffic volume.....	3,212			
Totals.....	\$ 650		\$32	
<u>Trucks, Heavy</u>				
Average speed (miles per hour)...	26.3	22.3		
Distance (miles).....	24.3	25.35		
Time (hours per trip).....	0.924	1.137		
Time savings per vehicle.....	0.213			
Value of savings (\$/vehicle-hour)	\$1.47			
Annual traffic volume.....	5,877			
Totals.....	\$ 1,840		\$111	
Total...Each Category.....	\$ 8,948		\$807	
TOTAL ANNUAL TIME ELEMENT SAVINGS.....			\$ 9,755	

e. Mileage Element Savings

As per tabulation which follows:

HIGHWAY PROJECT ANALYSIS

Mileage Element Savings

Location of project	MONTANA		County	CARTER	
Description of Project	EKALAKA-RIDGEWAY				
Highway number	FAS No. 323		Highway system	FA SECONDARY	
Length	35.0 Miles		Date of Analysis	MARCH 1946	
	Local Traffic		Diverted Traffic @ 37.2%		
Distance	New	Old	New	Old	
Length (miles).....	24.3	25.35			
Distance saving (miles).....	1.05				
Average annual traffic (tons).....	267,320				
Annual traffic saving (ton-mi.)....	280,686				
Cost (\$/ton-mile).....	\$0.0178				
Totals.....	\$ 4,996		\$ 2,158		
Surface					
Roadway surface type.....	0.167	0.25			
Saving coefficient.....	0.083				
Aver. annual traffic (ton-mi.).....	6,776,562				
Saving (\$/ton-mile).....	\$0.0015				
Totals.....	\$ 10,165		\$17		
Alignment					
Curvature rating.....	5.4	3.7			
Points improvement.....	1.7				
Saving (point-ton-miles).....	11,120,155				
Saving (\$/point-ton-mile).....	\$0.0001				
Totals.....	\$1,112		\$26		
Total...Each Category.....	\$16,273		\$2,201		
TOTAL ANNUAL MILEAGE ELEMENT SAVINGS.....			\$ 18,474		

f. Traffic Benefits
As per tabulation herebelow.

HIGHWAY PROJECT ANALYSIS

Traffic Benefits

Location of project	<u>MONTANA</u>	County	<u>CARTER</u>
Description of project	<u>EKALAKA-RIDGEWAY</u>		
Highway number	<u>FAS No. 323</u>	Highway system	<u>FA SECONDARY</u>
Length		Date of analysis	<u>MARCH 1946</u>

Mileage Element Factors

Item			Fuel Function	Non-fuel Function
Distance savings	<u>\$7,154</u>	<u>38%</u>	<u>\$2,719</u>	<u>\$4,435</u>
Roadway Surface Savings	<u>\$10,182</u>	<u>44%</u>	<u>4,480</u>	<u>5,707</u>
Alignment Savings	<u>\$1,138</u>	<u>50%</u>	<u>\$569</u>	<u>\$569</u>
Total Mileage Savings	<u>\$18,474</u>		<u>\$7,768</u>	<u>\$10,706</u>

Time Element Savings

Type of Traffic	Annual Value of Time Savings
Passenger cars	<u>\$ 3,325</u>
Trucks, light	<u>3,797</u>
Trucks, medium	<u>682</u>
Trucks, heavy	<u>1,951</u>
Total Time Savings	<u>\$ 9,755</u>

Recapitulation of Annual Benefits

Total Fuel Function Benefits	<u>\$ 7,768</u>
Non-fuel function (Mileage element factors)	<u>\$ 10,706</u>
benefits (Time element factors)	<u>\$ 9,755</u>
Total Non-fuel Function Benefits	<u>\$ 20,461</u>
TOTAL ANNUAL BENEFITS	<u>\$ 28,229</u>

G. Derivation of Quotients

Pertinent data are presented as shown on the tabulation herebelow:

HIGHWAY PROJECT ANALYSIS

Location of project	<u>MONTANA</u>	County	<u>CARTER</u>
Description of project	<u>EKALAKA-RIDGEWAY</u>		
Highway number	<u>FAS No. 323</u>	Highway system	<u>FA SECONDARY</u>
Length	<u>35.0 Miles</u>	Date of analysis	<u>MARCH 1946</u>
Iar' = \$	<u>8,386</u>	K ₁	<u>= 1.00</u>

(Derivation of Quotients cont'd)

$$\begin{aligned}
 C_a &= \$ \frac{34,239}{K_2} = \frac{840/7,768}{K_2} = 0.11 \\
 B_n &= \$ \frac{22,179}{K_3} = \frac{0.05/0.20}{K_3} = 0.25 \\
 B_f &= \$ \frac{7,768}{K_2 K_3} = \frac{0.11 \times 0.25}{K_2 K_3} = 0.03 \\
 K_1 C_a &= \$ \frac{34,239}{1 - K_2 K_3} = \frac{1.00 - 0.03}{1 - K_2 K_3} = 0.97 \\
 Q_s &= I_{ar} / K_1 C_a = \frac{8,386/34,239}{K_1 C_a} = 0.245 \\
 Q_{Bn} &= B_n / K_1 C_a = \frac{20,461/34,239}{K_1 C_a} = 0.60 \\
 Q_{Bf} &= B_f / K_1 C_a = \frac{7,768/34,239}{K_1 C_a} = 0.225 \\
 Q' s &= Q_s - K_2 K_3 Q_{Bf} = 0.245 - 0.03 \times 0.225 = 0.245 - 0.005 = 0.24 \\
 Q_c &= 0.707 (Q_s / Q_{Bn} / Q_{Bf} (1 - K_2 K_3)) = 0.707 (0.245 / 0.60 / 0.225 \times 0.97) \\
 &= 0.707 (0.245 / 0.60 / 0.22) \\
 &= 0.707 \times 1.065 \\
 &= 0.75
 \end{aligned}$$

Here we note the effect of the decrease in traffic volume along with the high cost of bridge construction in that the composite solvency quotient drops from 1.06 to 0.75.

3. EKALAKA-ALBION ROAD: Oiled Surface, 18.5 miles; gravel surface, 19.5 miles; total travel-distance, 38.0 miles.

a. Annual Cost Calculations

Details of construction costs are as follows:

Re-grading, 9.5 miles @ \$1,500 per mile.....	\$14,250
Grading, 28.5 miles @ \$4,000 per mile.....	\$114,000
Gravel Base & Surface, 38.0 miles @ \$3,500 per mile.....	\$133,000
Major Drainage Structures, bridges	
2 Steel, 200 feet @ \$150 per lineal foot.....	\$30,000
13 Timber, 780 feet @ \$100 per lineal foot.....	\$78,000
Minor Drainage Structures, 28.5 miles @ \$800 per mile.....	\$22,800
Oil Surface, 18.5 miles @ \$2,000 per mile.....	\$37,000
Rights-of-Way, 9 miles @ \$500 per mile.....	\$4,500
19.5 miles @ \$400 per mile.....	\$7,800

Engineering and Administration

Grading, gravel and oil, 9.0 miles @ \$1,000 per mile.. \$9,000
 Re-gravel and oil, 9.5 miles @ \$600 per mile..... \$5,700
 Grade and gravel, 19.5 miles @ \$800 per mile.....\$15,600
 Bridges, 5% of \$108,000..... \$5,400

Sub-total..... \$477,050

✓ 10% for contingencies..... \$47,705

Total construction costs, 38.0 miles..... \$524,755

These figures are condensed in the tabulation which is presented herebelow to arrive at an annual capital cost which comprehends application of interest and maintenance charges.

ANNUAL COST CALCULATIONS

Location of project MONTANA County CARTER
 Description of project EKALAKA-ALBION ROAD
 Highway number FAS No. 323 Highway system FA SECONDARY
 Length 38.0 Miles Date of analysis MARCH 1946

Item	CAPITAL COSTS			Annual
	Net Cost	Interest Rate	Amort. Period	Capital Cost
Rights of way, easements, etc.	\$ 12,300	2 $\frac{1}{2}$ %	20 years	\$ 789
Clearing, grading, etc.	128,250	"	"	8,221
Pavements and surfacing:				
Type Gravel, Base & Surface	133,000	"	"	8,525
Type Oil Surfacing	37,000	"	"	2,372
Structures:				
Type Major, 2 Steel	30,000	"	"	1,923
Type Minor, 13 timber	78,000	"	"	5,000
Type Minor	22,800	"	"	1,461
Engineering & Administration....	35,700	"	"	2,288
✓ 10% for contingencies.....	47,705	"	"	3,058
1. Total annual capital cost.....				<u>\$33,637</u>

2. Total annual maintenance cost 38.0 Miles @ \$100.00 \$ 3,800

TOTAL ANNUAL COSTS (1 ✓ 2) \$37,437

b. Average Daily Traffic, 1960

(1) Local Traffic

Data in reference to traffic volume and travel-distance are shown on page 37.

(2) Diverted Traffic

Diverted traffic in the amount shown in the first analyses will be effective over 40.4% of the total routing.

c. Annual Revenues

Revenues will accrue in the amount shown on page 38.

LOCAL TRAFFIC WITH TRAVEL-DISTANCE DATA AS OF
COMPLETION OF THE EKALAKA-ALBION ROAD SECTION
OF THE EKALAKA-ALZADA ROUTING

	EXISTING FACILITIES (Miles)				NEW FACILITIES (Miles)										
	PTW	APPROACH	TOTAL TRAVEL DISTANCE	NEW	APPROACH	TOTAL TRAVEL DISTANCE									
TRAFFIC															
CLASSIFIC'N	ADT	GRAVEL:UNIMP:OIL	UNIMP:OIL	GRAVEL:UNIMP:TOTAL	OIL:GRAVEL:OIL	UNIMP:OIL	GRAVEL:UNIMP: TOTAL								
Existing															
Traffic	220.0	6.15	9.65:0.95	9.3	0.95	6.15	18.95:26.05:8.8	3.95	0.95	11.3	9.75	3.95	11.3	25.00	
Diverted															
Traffic	8.8	1.05	21.0	0.15	3.05	0.15	1.05	24.05:25.25:6.05	6.7	0.15	9.7	6.2	6.7	9.7	22.60
All Local															
Traffic	228.8	5.95	10.2	0.9	9.05	0.9	5.95	19.15:26.00:8.7	4.05	0.9	11.2	9.6	4.05	11.2	24.85

Traffic Income

HIGHWAY PROJECT ANALYSIS Ekalaka-Albion

Location of project Montana Description of project Road County Carter
 Highway FAS #323 Highway System FA Secondary Length 38.0 mi. Date of analysis March 1946

Traffic Type	Average Annual Traffic				Average Annual :Unit Net : Total Annual :		
	Local Traffic		Diverted Traffic		:Road Use During: Revenues :		: Net Revenue :
	Vehicles	Ton	Vehicles	Ton	:Life of project:Per Ton Mi:		
	Miles		Miles		: Ton Mile		
: Passenger Cars - Montana	: 39,238	: 750,427	: 1,588	: 90,561	: 840,988	: \$0.002188	: \$1,840
: Passenger Cars - Foreign	: 1,679	: 32,117	: 273	: 15,560	: 47,677	: 0.001799	: 86
: Total passenger cars	: 40,917	: 782,544	: 1,861	: 106,121	: 888,665	:	: \$1,926
: Trucks, light	: 33,142	: 1,381,769	: 176	: 21,828	: 1,403,597	: 0.003248	: \$4,559
: Trucks, medium	: 3,358	: 294,563	: 43	: 11,399	: 305,962	: 0.002382	: 729
: Trucks, heavy	: 1,825	: 259,450	: 6	: 2,565	: 262,015	: 0.001619	: 424
: Trucks, semi-trailer	: 2,081	: 391,629	: 43	: 24,393	: 416,022	: 0.001543	: 642
: Trucks, full-trailer	: 985	: 287,474	: 17	: 14,362	: 301,836	: 0.001396	: 421
: Busses	: 1,204	: 138,159	: 44	: 14,876	: 153,035	: 0.001873	: 287
: Total trucks & busses	: 42,595	: 2,753,044	: 329	: 89,423	: 2,842,467	:	: \$7,062
: Total all vehicles	: 83,512	: 3,535,588	: 2,190	: 195,544	: 3,731,132	:	: \$8,988

Total Annual Income \$8,988

d. Time Element Savings
As shown herebelow.

HIGHWAY PROJECT ANALYSIS

Time Element Savings

Location of project	MONTANA	County	CARTER	
Description of project	EKALAKA-ALBION ROAD			
Highway number	FAS No. 323	Highway system	FA SECONDARY	
Length	38.0 Miles	Date of analysis	MARCH 1946	
	Local Traffic	Diverted Traffic @ 40.4%		
Annual Traffic Volume	New	Old	New	Old
Private Passenger cars (per year)	40,917			
Trucks, light (per year).....	33,142			
Trucks, medium(per year).....	3,358			
Trucks, heavy (per year).....	6,095			
Totals.....	83,512			
Private Passenger Cars				
Average speed (miles per hour)...	36.3	32.3		
Distance (Miles).....	24.85	26.0		
Time (hours per trip).....	0.684	0.805		
Time savings per vehicle.....	0.121			
Value of savings (\$/vehicle-hour)	\$0.60			
Annual traffic volume.....	40,917			
Totals.....	\$2,971		\$629	
Trucks, light				
Average speed (miles per hour)...	33.3	29.3		
Distance (miles).....	24.85	26.0		
Time (hours per trip).....	0.746	0.887		
Time savings per vehicle.....	0.141			
Value of savings (\$/vehicle-hour)	\$0.86			
Annual traffic volume.....	33,142			
Totals.....	\$ 4,019		\$92	
Trucks, medium				
Average speed (miles per hour)...	29.3	25.3		
Distance (miles).....	24.85	26.0		
Time (hours per trip).....	0.848	1.028		
Time savings per vehicle.....	0.180			
Value of savings (\$/vehicle-hour)	\$1.17			
Annual traffic volume.....	3,358			
Totals.....	\$707		\$34	
Trucks, heavy				
Average speed (miles per hour)...	26.3	22.3		
Distance (miles).....	24.85	26.0		
Time (hours per trip).....	0.945	1.166		
Time savings per vehicle.....	0.221			
Value of savings (\$/vehicle-hour)	\$1.47			
Annual traffic volume.....	6,095			
Totals.....	\$ 1,980		\$120	
Total...Each Category.....	\$ 9,677		\$875	
TOTAL ANNUAL TIME ELEMENT SAVINGS.....	\$ 10,552			

e. Mileage Element Savings
As shown herewith.

HIGHWAY PROJECT ANALYSIS

Mileage Element Savings

Location of project	MONTANA	County	CARTER
Description of project	EKALAKA-ALBION ROAD		
Highway number	FAS No. 323	Highway system	FA SECONDARY
Length	38.0 Miles	Date of analysis	MARCH 1946

	Local Traffic		Diverted Traffic @ 40.4%	
Distance	New	Old	New	Old
Length (miles).....	24.85	26.0		
Distance saving (miles).....	1.15			
Average annual traffic (tons).....	277,301			
Annual traffic saving (ton-mi.)...	318,896			
Cost (\$/ton-mile).....	\$0.0178			
Totals.....	\$ 5,676		\$ 2,343	

Surface				
Roadway surface type.....	0.169	0.251		
Saving coefficient.....	0.082			
Aver. annual traffic (ton-mi.)....	7,209,896			
Saving (\$/ton-mile).....	\$0.00146			
Totals.....	\$ 10,526		\$19	

Alignment				
Curvature rating.....	5.5	2.7		
Points improvement.....	2.8			
Saving (point-ton-miles).....	20,187,709			
Saving (\$/point-ton-mile).....	\$0.0001			
Totals.....	\$ 2,019		\$28	
Total...Each Category.....	\$18,221		\$2,390	
TOTAL ANNUAL MILEAGE ELEMENT SAVINGS.....			\$ 20,611	

f. Traffic Benefits

Non-fuel benefits and fuel benefits are allocated as shown here-
below.

HIGHWAY PROJECT ANALYSIS

Traffic Benefits

Location of project	MONTANA	County	CARTER
Description of project	EKALAKA - ALBION ROAD		
Highway number	FAS No. 323	Highway system	FA SECONDARY
Length	38.0 Miles	Date of analysis	MARCH 1946

Mileage Element Factors				
Item			Fuel Function	Non-fuel Function
Distance savings	\$8,019	38%	\$ 3,047	\$ 4,972

(Traffic Benefits cont'd)

Item			Fuel Function	Non-fuel Function
Roadway surface savings	\$10,545	44.5%	\$ 4,693	\$ 5,852
Alignment savings	2,047	50%	1,023	1,024
Total Mileage Savings	\$20,611		\$ 8,763	\$ 11,848

Time Element Factors

Type of Traffic	Annual Value of Time Savings
Passenger cars	\$ 3,600
Trucks, light	4,111
Trucks, medium	741
Trucks, heavy	2,100
Total Time Savings	\$ 10,552

Recapitulation of Annual Benefits

Total Fuel Function Benefits	\$ 8,763
Non-fuel function (Mileage element factors	\$ 11,848
benefits (Time element factors	\$ 10,552
Total Non-fuel Function Benefits	\$22,400
TOTAL ANNUAL BENEFITS	\$31,163

g. Derivation of Quotients

Almost identical with that shown on the next previous analysis.

HIGHWAY PROJECT ANALYSIS

Location of project	MONTANA	County	CARTER
Description of project	EKALAKA-ALBION ROAD		
Highway number	FAS No. 323	Highway system	FA SECONDARY
Length	38.0 Miles	Date of analysis	MARCH 1946

$I_{ar} = \$$	8,988	K_1	$= 1.00$
$C_a = \$$	37,437	K_2	$= 913/8,763 = 0.105$
$B_n = \$$	22,400	K_3	$= 0.05/0.20 = 0.25$
$B_f = \$$	8,763	$K_2 K_3$	$= 0.105 \times 0.25 = 0.025$
$K_1 C_a = \$$	37,437	$1 - K_2 K_3$	$= 1.00 - 0.025 = 0.975$

(Derivation of Quotients cont'd)

$$\begin{aligned}
 Q_s &= I_{ar} / K_1 C_a = 8,988 / 37,437 = 0.24 \\
 Q_{Bn} &= B_n / K_1 C_a = 22,400 / 37,437 = 0.60 \\
 Q_{Bf} &= B_f / K_1 C_a = 8,763 / 37,437 = 0.235 \\
 Q' &= Q_s - K_2 K_3 Q_{Bf} = 0.24 - 0.025 \times 0.235 = 0.24 - 0.005 = 0.235 \\
 Q_c &= 0.707 (Q_s / Q_{Bn} / Q_{Bf} (1 - K_2 K_3)) = 0.707 (0.24 / 0.60 / 0.235 \times 0.975) \\
 &= 0.707 (0.24 / 0.60 / 0.23) \\
 &= 0.707 \times 1.07 \\
 &= 0.755
 \end{aligned}$$

4. EKALAKA-ALZADA ROAD; Oiled Surface 18.5 miles, Gravel Surface 30.0 miles, total travel-distance 48.5 miles.

a. Annual Cost Calculations

Details of construction costs are as follows:

Re-grading, 9.5 miles @ \$1,500 per mile.....	\$14,250
Grading, 39 miles @ \$4,000 per mile.....	\$156,000
Gravel Base and Surface, 48.5 miles @ \$3,500 per mile.....	\$169,750
Major Drainage Structures, bridges	
2 Steel, 200 feet @ \$150 per lineal foot.....	\$30,000
16 Timber, 960 feet @ \$100 per lineal foot.....	\$96,000
Minor Drainage Structures, 39 miles @ \$800 per mile.....	\$31,200
Oiled Surface, 18.5 miles @ \$2,000 per mile.....	\$37,000
Rights-of-Way	
9 miles @ \$500 per mile.....	\$4,500
30 miles @ \$400 per mile.....	\$12,000
Engineering and Administration	
Grading, gravel and oil 9 miles @ \$1,000 per mile.....	\$9,000
Re-gravel and oil 9.5 miles @ \$600 per mile.....	\$5,700
Grade and gravel 30 miles @ \$800 per mile.....	\$24,000
Bridges, 5% of \$126,000.....	\$6,300
Sub-total.....	\$595,700
+ 10% for contingencies.....	\$59,570
Total construction cost, 48.5 miles.....	\$655,270

These data are condensed in the tabulation which is presented here-
below to arrive at an annual capital cost which comprehends application of
interest and maintenance charges.

ANNUAL COST CALCULATIONS

Location of project	MONTANA	County	CARTER
Description of project	EKALAKA-ALZADA ROAD		
Highway number	FAS No. 323	Highway system	FA SECONDARY
Length	48.5 Miles	Date of analysis	MARCH 1946

	CAPITAL COSTS			Annual
	Net Cost	Interest Rate	Amort. Period	Capital Cost
Rights of way, easements, etc.	\$ 16,500	2 $\frac{1}{2}$ %	20 yrs.	\$ 1,057
Clearing, grading, etc.	170,250	"	"	10,913
Pavements and surfacing:				
Type Gravel Base & Surface	169,750	"	"	10,881
Type Oil Surface	37,000	"	"	2,372
Structures:				
Type Major, 2 Steel	30,000	"	"	1,923
Type Major, 16 Timber	96,000	"	"	6,154
Type Minor	31,200	"	"	2,000
Engineering & Administration....	45,000	"	"	2,884
✓ 10% for contingencies.....	59,570	"	"	3,819
1. Total annual capital cost.....				\$42,003
2. Total annual maintenance cost 48.5 miles @ \$100.00				\$ 4,850
TOTAL ANNUAL COSTS (1 ✓ 2)				\$46,853

b. Average Daily Traffic, 1960

(1) Local Traffic

Tabulation of local traffic in terms of volume and travel-
distance is shown on page 44.

(2) Diverted Traffic

Effective in the amount of 51.5% in so far as travel-distance
and volume are concerned.

c. Annual Revenues

We can expect revenues in the amount shown on page 45.

d. Time Element Savings

Tabulation as follows:

HIGHWAY PROJECT ANALYSIS

			Time Element Savings
Location of project	MONTANA	County	CARTER
Description of project	EKALAKA-ALZADA ROAD		
Highway number	FAS No. 323	Highway system	FA SECONDARY
Length	48.5 Miles	Date of analysis	MARCH 1946

(cont'd on page 46)

LOCAL TRAFFIC WITH TRAVEL-DISTANCE DATA AS OF
COMPLETION OF THE EKALAKA-ALZADA ROAD SECTION
OF THE EKALAKA-ALZADA ROUTING

	EXISTING FACILITIES (Miles)				NEW FACILITIES (Miles)			
	PTW	APPROACH	TOTAL TRAVEL-DISTANCE	NEW	APPROACH	TOTAL TRAVEL-DISTANCE		
TRAFFIC								
CLASSIFIC'N	ADT	GRAVEL:UNIMP	OIL:GRAVEL:UNIMP:TOTAL	OIL:GRAVEL	OIL:UNIMP	OIL:GRAVEL:UNIMP:TOTAL		
Existing								
Traffic	232.0	5.8	9.8	1.55:9.35	1.55	5.8	19.15:26.5	8.35: 5.1 :1.55: 10.6: 9.9: 5.1 :10.6 : 25.6
Diverted								
Traffic	9.15	1.05	20.2	0.15:2.95	0.15	1.05	23.15:24.35	5.8 : 7.65 :0.75: 7.95: 6.55: 7.65 : 7.95: 22.15:
All Local								
Traffic	241.5	5.6	10.2	1.5 :9.1	1.5	5.6	19.3 :26.4	8.25: 5.2 :1.5 : 10.5: 9.75 5.2 :10.5 : 25.45:

HIGHWAY PROJECT ANALYSIS

Traffic Income

Location of project Montana Highway FAS #323 Description of project Ekalaka - Alzada Road Length 48.5 miles Date of analysis March 1946

Traffic Type	Average Annual Traffic			Average Annual			Unit Net: Total Annual		
	Local Traffic	Diverted Traffic	Traffic	Road Use During	Revenues: Net Revenue	Life of Project: per Ton Mi:	Revenues: Net Revenue	Life of Project: per Ton Mi:	Revenues: Net Revenue
	Vehicles : Ton : Miles	Vehicles : Ton : Miles	Vehicles : Ton : Miles	Vehicles : Ton : Miles	Vehicles : Ton : Miles	Vehicles : Ton : Miles	Vehicles : Ton : Miles	Vehicles : Ton : Miles	Vehicles : Ton : Miles
Passenger Cars - Montana	41,373	834,707	1,588	115,610	950,307	\$0.002188	\$ 2,079		
Passenger Cars - Foreign	1,752	35,347	273	19,863	55,210	0.001799	99		
Total passenger cars	43,125	870,054	1,861	135,473	1,005,527		\$ 2,178		
Trucks, light	34,967	1,537,900	176	27,865	1,565,765	0.003248	\$ 5,086		
Trucks, medium	3,504	324,253	43	14,550	338,803	0.002382	807		
Trucks, heavy	1,935	290,184	6	3,275	293,459	0.001619	475		
Trucks, semi-trailer	2,190	434,758	43	31,140	465,898	0.001543	719		
Trucks, full-trailer	1,058	325,732	17	18,335	344,067	0.001396	480		
Busses	1,241	150,223	44	18,990	169,213	0.001873	317		
Total trucks & busses	44,895	3,063,050	329	114,155	3,177,205		\$ 7,884		
Total all vehicles	88,020	3,933,104	2,190	249,628	4,182,732		\$10,062		

Total Annual Income..... \$10,062

	Local Traffic		Diverted Traffic @ 51.6%	
	New	Old	New	Old
<u>Annual Traffic Volume</u>				
Private Passenger cars (per year)	43,125			
Trucks, light (per year).....	34,967			
Trucks, medium (per year).....	3,504			
Trucks, heavy (per year).....	6,424			
Totals.....	88,020			
<u>Private Passenger Cars</u>				
Average speed (miles per hour)...	36.6	32.4		
Distance (Miles).....	25.45	26.4		
Time (hours per trip).....	0.695	0.815		
Time savings per vehicle.....	0.120			
Value of savings (\$/vehicle-hour)	\$0.60			
Annual traffic volume.....	43,125			
Totals.....	\$ 3,105		\$803	
<u>Trucks, light</u>				
Average speed (miles per hour)...	33.6	29.4		
Distance (miles).....	25.45	26.4		
Time (hours per trip).....	0.757	0.898		
Time savings per vehicle.....	0.141			
Value of savings (\$/vehicle-hour)	\$0.86			
Annual traffic volume.....	34,967			
Totals.....	\$ 4,240		\$118	
<u>Trucks, medium</u>				
Average speed (miles per hour)...	29.6	25.4		
Distance (miles).....	25.45	26.4		
Time (hours per trip).....	0.860	1.039		
Time savings per vehicle.....	0.179			
Value of savings (\$/vehicle-hour)	\$1.17			
Annual traffic volume.....	3,504			
Totals.....	\$ 734		\$44	
<u>Trucks, heavy</u>				
Average speed (miles per hour)...	26.6	22.4		
Distance (miles).....	25.45	26.4		
Time (hours per trip).....	0.957	1.179		
Time savings per vehicle.....	0.222			
Value of savings (\$/vehicle-hour)	\$1.47			
Annual traffic volume.....	6,424			
Totals.....	\$ 2,096		\$154	
Total...Each Category.....	\$ 10,175		\$1,119	
TOTAL ANNUAL TIME ELEMENT SAVINGS.....	\$ 11,294			

e. Mileage Element Savings
Tabulation as follows:

HIGHWAY PROJECT ANALYSIS

Location of project		MONTANA	County	Mileage Element Savings CARTER
Description of Project		EKALAKA-ALZADA ROAD		
Highway number		FAS No. 323	Highway system	FA SECONDARY
Length		48.5 Miles	Date of analysis	MARCH 1946

(Mileage Element Savings cont'd)

	Local Traffic		Diverted Traffic @ 51.6%	
	New	Old	New	Old
Distance				
Length (miles).....	25.45	26.4		
Distance saving (miles).....	0.95			
Average annual traffic (tons).....	292,424			
Annual traffic saving (ton-mi.)...	277,803			
Cost (\$/ton-mile).....	\$0.0178			
Total.....	\$ 4,945		\$2,993	
Surface				
Roadway surface type.....	0.166	0.247		
Saving coefficient.....	0.181			
Aver. annual traffic (ton-mi.)....	7,719,794			
Saving (\$/ton-mile).....	0.00144			
Total.....	\$11,117		\$24	
Alignment				
Curvature rating.....	5.9	2.7		
Points improvement.....	3.2			
Saving (point-ton-miles).....	24,703,341			
Saving (\$/point-ton-mile).....	0.0001			
Total.....	\$ 2,470		\$36	
Total....Each Category.....	\$ 18,532		\$3,053	
TOTAL ANNUAL MILEAGE ELEMENT SAVINGS.....\$ 21,585				

f. Traffic Benefits

Allocating non-fuel benefits and fuel benefits in the proportions advanced by the Oregon Highway Department we have results as follows:

HIGHWAY PROJECT ANALYSIS

Traffic Benefits

Location of project	MONTANA	County	CARTER
Description of project	EKALAKA-ALZADA ROAD		
Highway number	FAS No. 323	Highway system	FA SECONDARY
Length	48.5 Miles	Date of analysis	March 1946

Mileage Element Factors

Item		Fuel Function	Non-fuel Function
Distance savings	\$7,938 38%	\$ 3,016	\$ 4,922
Roadway surface savings	\$11,141 45.5%	5,069	6,072
Alignment savings	\$2,506 50%	1,253	1,253
Total Mileage Savings	\$21,585	\$ 9,338	\$ 12,247

Time Element Factors

Type of Traffic	Annual Value of Time Savings
Passenger cars	\$ 3,908

(Traffic Benefits cont'd)

Trucks, light	\$ 4,358
Trucks, medium	778
Trucks, heavy	2,250
Total Time Savings	\$11,294

Recapitulation of Annual Benefits

Total Fuel Function Benefits	\$ 9,338
Non-fuel function (Mileage element factors	\$ 12,247
benefits (Time element factors	\$ 11,294
Total Non-fuel Function Benefits	\$23,541
TOTAL ANNUAL BENEFITS	\$32,879

g. Derivation of Quotients
Tabulation as follows:

HIGHWAY PROJECT ANALYSIS

Location of project	MONTANA	County	CARTER
Description of project	EKALAKA-ALZADA ROAD		
Highway number	FAS No. 323	Highway system	FA SECONDARY
Length	48.5 Miles	Date of Analysis	MARCH 1946

$$\begin{aligned}
 I_{ar} &= \$ 10,062 & K_1 &= 1.00 \\
 C_a &= \$ 54,830 & K_2 &= 1,165/9,338 = 0.125 \\
 B_n &= \$ 23,541 & K_3 &= 0.05/0.20 = 0.25 \\
 B_f &= \$ 9,338 & K_2 K_3 &= 0.125 \times 0.25 = 0.03 \\
 K_1 C_a &= \$ 54,830 & 1 - K_2 K_3 &= 1.00 - 0.03 = 0.97 \\
 Q_s &= I_{ar}/K_1 C_a = 10,062/46,853 = 0.215 \\
 Q_{Bn} &= B_n/K_1 C_a = 23,541/46,853 = 0.50 \\
 Q_{Bf} &= B_f/K_1 C_a = 9,338/46,853 = 0.20 \\
 Q'_s &= Q_s - K_2 K_3 Q_{Bf} = 0.215 - 0.03 \times 0.20 = 0.215 - 0.005 = 0.21 \\
 Q_c &= 0.707 (Q_s/Q_{Bn}/Q_{Bf}(1 - K_2 K_3)) = 0.707 (0.215/0.50/0.20 \times 0.98) \\
 &= 0.707 (0.215/0.50/0.195) \\
 &= 0.707 \times 0.91 \\
 &= 0.645
 \end{aligned}$$

Note drop in over all solvency as a circumstance of decreased traffic volumes as the analyses carry the routing closer to the southerly section of the county. As a matter of fact this interval determines or locates the split between local traffic proceeding north to or through Ekalaka and that traffic which proceeds in a southerly direction bound for or through Alzada.

5. EKALAKA-HAMMOND; Oiled Surface, 18.5 miles, Gravel Surface 47.5 miles total travel-distance 66 miles.

a. Annual Cost Calculations

Construction costs are summarized as follows: -

Re-grading, 9.5 miles @ \$1,500 per mile.....	\$14,250
Grading, 56.5 miles @ \$4,000 per mile.....	\$226,000
Gravel Base and Surface, 66 miles @ \$3,500 per mile.....	\$231,000
Major Drainage Structures, bridges	
2 Steel, 200 feet @ \$150 per lineal foot.....	\$30,000
20 Timber, 1,200 feet @ \$100 per lineal foot.....	\$120,000
Minor Drainage Structures, 56.5 miles @ \$800 per mile.....	\$45,200
Oiled Surface, 18.5 miles @ \$2,000 per mile.....	\$37,000
Rights-of-Way	
9 miles @ \$500 per mile.....	\$4,500
47.5 miles @ \$400 per mile.....	\$19,000
Engineering and Administration	
Grading, gravel, and oil 9 miles @ \$1,000 per mile.....	\$9,000
Re-gravel and oil 9.5 miles @ \$600 per mile.....	\$5,700
Grade and gravel 47.5 miles @ \$800 per mile.....	\$38,000
Bridges, 5% of \$150,000.....	\$7,500

Sub-total.....\$787,150

/ 10% for contingencies..... \$78,715

Total construction cost, 66 miles.....\$865,865

These data are summarized and extended in the tabulation presented herebelow to arrive at an annual capital cost which comprehends an interest charge and maintenance costs.

ANNUAL COST CALCULATIONS

Location of project	MONTANA	County	CARTER
Description of project	EKALAKA-HAMMOND		
Highway number	FAS No. 323	Highway system	FA SECONDARY
Length	66.0 Miles	Date of Analysis	MARCH 1946

(Annual Cost Calculations cont'd)

Item,	CAPITAL COSTS			Annual
	Net Cost	Interest Rate	Amort. Period	Capital Cost
Rights of way, easements, etc.	\$ 23,500	2 $\frac{1}{2}$ %	20 yrs.	\$ 1,506
Clearing, grading etc.	240,250	"	"	15,400
Pavements and surfacing:				
Type Gravel Base & Surface	231,000	"	"	14,807
Type Oil Surface	37,000	"	"	2,372
Structures:				
Type Major 2 Steel	30,000	"	"	1,923
Type Major 20 Timber	120,000	"	"	7,692
Type Minor	45,200	"	"	2,897
Engineering & Administration...	60,200	"	"	3,859
✓ 10% for contingencies.....	78,715	"	"	5,046
1. Total annual capital cost.....				\$ 55,502
2. Total annual maintenance cost	66.0 miles @ \$100.00			\$ 6,600
TOTAL ANNUAL COSTS (1 ✓ 2)				\$ 62,102

b. Average Daily Traffic, 1960

(1) Local Traffic

Tabulation of local traffic in terms of volume and travel-distance is shown on page 51.

(2) Diverted Traffic

Effective over 70.2% of the length of the total routing.

c. Annual Revenues

Tabulation as shown on page 52.

d. Time Element Savings

Tabulation as follows:

HIGHWAY PROJECT ANALYSIS

Time Element Savings

Location of project	MONTANA	County	CARTER	
Description of project	EKALAKA-HAMMOND			
Highway number	FAS No. 323	Highway system	FA SECONDARY	
Length	66.0 Miles	Date of analysis	March 1946	
	Local Traffic	Diverted Traffic @ 70.2%		
Annual Traffic Volume	New	Old	New	Old
Private passenger cars (per year)	51,100			
Trucks, light (per year).....	41,409			
Trucks, medium (per year).....	4,179			
Trucks, heavy (per year).....	7,611			
Totals.....	104,299			

(cont'd on page 53.)

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	EXISTING FACILITIES (Miles)				NEW FACILITIES (Miles)			
	PTW	APPROACH	TOTAL TRAVEL DISTANCE	NEW	APPROACH	TOTAL TRAVEL DISTANCE		
TRAFFIC								
CLASSIFICATION	ADT	GRAVEL:UNIMP	OIL:UNIMP:OIL:GRAVEL:UNIMP:TOTAL	OIL:GRAVEL:OIL:UNIMP:OIL:GRAVEL:UNIMP:TOTAL				
Existing								
Traffic	:277.0	:4.85 :10.05:5.35: 8.25:5.35: 4.85 :18.3 :28.5 :6.95: 7.15 :5.3 :8.35 :12.25: 7.15 :8.35 :27.75						
Diverted								
Traffic	: 8.75: 1.1 :21.2 :0.15: 3.1 :0.15: 1.1 :24.3 :25.55:6.1 : 8.0 :0.8 :8.3 : 6.9: 8.0 :8.3 :23.2							
Local								
Traffic	:285.75: 4.75 :10.2 :5.2 : 8.1 :5.2 : 4.75 :18.5 :28.45:6.9 : 7.2 :5.15:8.35 :12.05 7.2 :8.35 :27.6							

HIGHWAY PROJECT ANALYSIS

Location of project Highway FAS #323	Montana	Description of project Highway System FA Secondary	Ekalaka - Hammond	Length 66.0 miles	Traffic Income	
					County	Carter
				Date of Analysis	March 1946	

Traffic Type	Average Annual Traffic			Average Annual			Unit Net			Total Annual		
	Local Traffic			Diverted Traffic			Road Use During			Revenues		
	Vehicles	Ton	Miles	Vehicles	Ton	Miles	Life of Project	Per Ton	Mi			
Passenger Cars - Montana	49,020	1,036,773	1,588	157,305	1,194,078	\$0.002188				\$ 2,613		
Passenger Cars - Foreign	2,080	43,992	273	27,025	71,017	0.001799				128		
Total passenger cars	51,100	1,080,765	1,861	184,330	1,265,095					\$ 2,741		
Trucks, light	41,409	1,909,239	176	37,916	1,947,155	0.003248				\$ 6,324		
Trucks, medium	4,179	405,403	43	19,800	425,203	0.002382				1,013		
Trucks, heavy	2,300	361,595	6	4,455	366,050	0.001619				593		
Trucks, semi-trailer	2,610	543,188	43	42,370	585,558	0.001543				904		
Trucks, full-trailer	1,241	400,525	17	24,947	425,472	0.001396				594		
Busses	1,460	185,274	14	25,837	211,111	0.001873				395		
Total trucks & busses	53,199	3,805,224	329	155,325	3,960,519					\$ 9,823		
Total all vehicles	104,299	4,885,989	2,190	339,655	5,225,644					\$ 12,564		

Total Annual Income..... \$12,564

		(Time Element Savings cont'd)			
Private Passenger Cars		New	Old	New	Old
Average speed (miles per hour).....	37.8	33.7			
Distance (Miles).....	27.6	28.45			
Time (hours per trip).....	0.730	0.844			
Time savings per vehicle.....	0.114				
Value of savings (\$/vehicle-hour)...	\$0.60				
Annual traffic volume.....	51,000				
Total.....	\$ 3,495			\$1,093	
Trucks, Light					
Average speed (miles per hour).....	34.8	30.7			
Distance (miles).....	27.6	28.45			
Time (hours per trip).....	0.793	0.927			
Time savings per vehicle.....	0.134				
Value of savings (\$/vehicle-hour)...	\$0.86				
Annual traffic volume.....	41,409				
Total.....	\$ 4,772			\$160	
Trucks, Medium					
Average speed (miles per hour).....	30.8	26.7			
Distance (miles).....	27.6	28.45			
Time (hours per trip).....	0.896	1.066			
Time savings per vehicle.....	0.170				
Value of savings (\$/vehicle-hour)...	\$1.17				
Annual traffic volume.....	4,179				
Total.....	\$ 831			\$60	
Trucks, Heavy					
Average speed (miles per hour).....	27.8	23.7			
Distance (miles).....	27.6	28.45			
Time (hours per trip).....	0.993	1.200			
Time savings per vehicle.....	0.207				
Value of savings (\$/vehicle-hour)...	\$1.47				
Annual traffic volume.....	7,611				
Total.....	\$ 2,316			\$209	
Total....Each Category.....	\$ 11,414			\$1,522	
TOTAL ANNUAL TIME ELEMENT SAVINGS.....		\$ 12,936			

e. Mileage Element Savings
Tabulation as follows:

		Mileage Element Savings			
Location of project		MONTANA		County	
Description of Project		EKALAKA-HAMMOND		CARTER	
Highway number		FAS No. 323		Highway system	
Length		66.0 Miles		Date of Analysis	
				March 1946	
				Local Traffic	
				Diverted Traffic	
				@ 70.2%	
Distance		New	Old	New	Old
Length (miles).....		27.6	28.45		
Distance saving (miles).....		0.85			
Average annual traffic (tons).....		346,524			
Annual traffic saving (ton-mi.)...		294,545			
Cost (\$/ton-mile).....		0.0178			
Total.....		\$ 5,243		\$4,072	

(Mileage Element Savings cont'd)

Surface	New	Old	New	Old
Roadway surface type.....	0.147	0.219		
Saving coefficient.....	0.072			
Aver. annual traffic (ton-mi.)..	9,858,608			
Saving (\$/ton-mile).....	0.0013			
Total.....	\$12,816		\$33	
Alignment				
Curvature rating.....	7.0	3.5		
Points improvement.....	3.5			
Saving (point-ton-miles).....	34,505,128			
Total.....	\$ 3,450		\$49	
Total....Each Category.....	\$ 21,509		\$4,154	

TOTAL ANNUAL MILEAGE ELEMENT SAVINGS.....\$ 25,663

f. Traffic Benefits

Tabulation as follows:

HIGHWAY PROJECT ANALYSIS

Location of project	MONTANA	County	Traffic Benefits
Description of project	EKALAKA-HAMMOND		CARTER
Highway number	FAS No. 323	Highway system	FA SECONDARY
Length	66.0 Miles	Date of analysis	MARCH 1946
Mileage Element Factors			

Item			Fuel Function	Non-fuel Function
Distance savings	\$9,315	38%	\$ 3,540	\$ 5,775
Roadway surface savings	\$12,849	50.5%	6,489	6,360
Alignment savings	\$3,499	50%	1,750	1,749
Total Mileage Savings	\$25,663		\$ 11,779	\$ 13,884

Time Element Factors

Type of Traffic	Annual Value of Time Savings
Passenger cars	\$ 4,588
Trucks, light	4,932
Trucks, medium	891
Trucks, heavy	2,525
Total Time Savings	\$ 12,936

Recapitulation of Annual Benefits

Total Fuel Function Benefits	\$ 11,779
Non-fuel function (Mileage element factors	\$ 13,884
benefits (Time element factors	\$ 12,936
Total Non-fuel Function Benefits	\$ 26,820
TOTAL ANNUAL BENEFITS	\$ 38,599

g. Derivation of Quotients
Tabulation as follows:

HIGHWAY PROJECT ANALYSIS

Location of project	MONTANA	County	CARTER
Description of project	EKALAKA-HAMMOND		
Highway number	FAS No. 323	Highway system	FA SECONDARY
Length	66.0 Miles	Date of analysis	MARCH 1946

$$I_{ar} = \$ 12,564 \quad K_1 = 1.00$$

$$C_a = \$ 62,102 \quad K_2 = 1,589/11,779 = 0.135$$

$$B_n = \$ 26,820 \quad K_3 = 0.05/0.20 = 0.25$$

$$B_f = \$ 11,779 \quad K_2 K_3 = 0.135 \times 0.25 = 0.035$$

$$K_1 C_a = \$ 62,102 \quad 1 - K_2 K_3 = 1.00 - 0.035 = 0.965$$

$$Q_s = I_{ar} / K_1 C_a = 12,564 / 62,102 = 0.20$$

$$Q_{Bn} = B_n / K_1 C_a = 26,820 / 62,102 = 0.43$$

$$Q_{Bf} = B_f / K_1 C_a = 11,779 / 62,102 = 0.19$$

$$Q's = Q_s - K_2 K_3 Q_{Bf} = 0.20 - 0.035 \times 0.19 = 0.20 - 0.005 = 0.195$$

$$Q_c = 0.707 (Q_s / Q_{Bn} / Q_{Bf} (1 - K_2 K_3)) = 0.707 (0.20 / 0.43 / 0.19 \times 0.965)$$

$$= 0.707 (0.20 / 0.43 / 0.185)$$

$$= 0.707 \times 0.815$$

$$= 0.575$$

Note the small value of the composite quotients, this despite the fact that traffic volumes are increasing as the routing proceeds from the Alzada road turn-off towards Hammond.

6. EKALAKA-ALZADA; Oiled Surface 46.5 miles, gravel surface 47.5 miles.

a. Annual Cost Calculations

Construction costs as estimated are summarized herebelow.

Re-grading, 9.5 miles @ \$1,500 per mile..... \$14,250

Grading, 56.5 miles @ \$4,000 per mile.....\$226,000

Gravel Base and Surface, 66 miles @ \$3,500 per mile.....\$231,000

Major Drainage Structures, bridges

2 Steel, 200 feet @ \$150 per lineal foot..... \$30,000

20 Timber, 1,200 feet @ \$100 per lineal foot.....\$120,000

Minor Drainage Structures, 56.6 miles @ \$800 per mile..... \$45,200

Oiled Surface, 18.5 miles @ \$2,000 per mile..... \$37,000

Rights-of-Way

9 miles @ \$500 per mile..... \$4,500

47.5 miles @ \$400 per mile..... \$23,500

Engineering and Administration

Grading, gravel and oil 9 miles @ \$1,000 per mile..... \$9,000

Re-gravel and oil 9.5 miles @ \$600 per mile..... \$5,700

Grade and gravel 47.5 miles @ \$800 per mile..... \$38,000

Bridges, 5% of \$150,000..... \$7,500

Sub-total.....\$787,150

✓ 10% for contingencies..... \$78,715

Total construction cost 94.0 miles.....\$865,865

That traffic involved in this particular analysis which will proceed from or to Alzada between that town and Hammond must assume a certain proportion of the unamortized cost of the original construction along that interval, 28 miles. On the basis of traffic volume it is estimated that this cost will be \$76,003, this value when added to the construction cost of the new work renders a total construction cost of \$941,868 for the whole of the routing between Ekalaka and Alzada.

These data are summarized and extended to arrive at an annual capital cost which comprehends the application of an interest charge and maintenance costs.

ANNUAL COST CALCULATIONS

Location of project MONTANA County CARTER
Description of project EKALAKA-ALZADA
Highway number FAS No. 323 & FA No. 23 Highway system FA SECONDARY & FA PRIMARY
Length 94.0 Miles Date of analysis March 1946

Item	CAPITAL COSTS			Annual Capital Cost
	Net Cost	Interest Rate	Amort. Period	
Rights of way, easements, etc.	\$ 23,500	2 $\frac{1}{2}$ %	20 yrs.	\$ 1,506
Clearing, grading, etc.	240,250	"	"	15,400
Pavements and surfacing:				
Type Gravel Base & Surface	231,000	"	"	14,807
Type Oil Surface	37,000	"	"	2,372
Structures:				
Type Major 2 Steel	30,000	"	"	1,923
Type Major 20 Timber	120,000	"	"	7,692
Type Minor	45,200	"	"	2,897
Engineering & Administration....	60,200	"	"	3,859
✓ 10% for contingencies.....	78,715	"	"	5,046
Unamortized cost old const.....	76,003	"	"	4,872

(Annual Cost Calculations cont'd)

1. Total annual capital cost.....	\$ 60,374
2. Total annual maintenance cost 66.0 Miles @ \$100.00....	\$ 7,944
28.0 Miles @ \$ 48.00....	
TOTAL ANNUAL COSTS (1 + 2).....	\$ 68,318

b. Average Daily Traffic, 1960

(1) Local Traffic

Tabulation as shown on page 58.

(2) Diverted Traffic

Diverted traffic will be effective over 100% of the Ekalaka-Alzada routing.

c. Annual Revenues

Tabulation as shown on page 59.

d. Time Element Savings

Tabulation as follows:

HIGHWAY PROJECT ANALYSIS

Location of project		Time Element Savings	
MONTANA		CARTER	
Description of project		EKKALAKA-ALZADA	
Highway number FAS No. 323 & FA No. 23		Highway System FA SECONDARY & FA PRIMARY	
Length 94.0 Miles		Date of analysis MARCH 1946	
		Local Traffic	Diverted Traffic
		@ 100%	
Annual Traffic Volume		New	Old
Private Passenger cars (per year)		50,844	
Trucks, light (per year).....		41,172	
Trucks, medium (per year).....		4,161	
Trucks, heavy (per year).....		7,556	
Totals.....		103,733	
Private Passenger Cars			
Average speed (miles per hour)...		37.8	33.7
Distance (Miles).....		27.75	28.55
Time (hours per trip).....		0.734	0.847
Time savings per vehicle.....		0.113	
Value of savings (\$/vehicle-hour)		\$0.60	
Annual traffic volume.....		50,844	
Totals.....		\$ 3,447	\$1,557
Trucks, Light			
Average speed (miles per hour)...		34.8	30.7
Distance (miles).....		27.75	28.55
Time (hours per trip).....		0.797	0.930
Time savings per vehicle.....		0.133	
Value of savings (\$/vehicle-hour)		\$0.86	
Annual traffic volume.....		41,172	
Total.....		\$ 4,709	\$228

LOCAL TRAFFIC WITH TRAVEL-DISTANCE DATA AS OF COMPLETION
OF THE EKALAKA-HAMMOND SECTION OF THE EKALAKA-ALZADA ROUTING
AND EXTENSION OF ROUTE TRAVEL TO ALZADA

EXISTING FACILITIES (Miles)										NEW FACILITIES (Miles)									

HIGHWAY PROJECT ANALYSIS

Traffic Income

Location of project Montana Description of project Ekalaka - Alzada County Carter
 Highway FAS No. 323 & Highway System FA Secondary & Length 94.0 miles Date of analysis March, 1946
FA No. 23 FA Primary

Traffic Type	Average Annual Traffic			Average Annual			Unit Net : Total Annual		
	Local Traffic			Diverted Traffic			Road Use During: Revenues : Net Revenues :		
	Vehicles : Ton	Vehicles	Ton	Miles	Miles	Ton Miles	Life of Project: Per Ton Mi:		
Passenger Cars - Montana	48,764	1,254,454	1,588	224,049	1,478,503	\$0.002188	\$	3,235	
Passenger Cars - Foreign	2,080	53,508	273	38,493	92,001	0.001799		165	
Total passenger cars	50,844	1,307,962	1,861	262,542	1,570,504			\$	3,400
Trucks, light	41,172	2,308,939	176	54,003	2,362,942	0.003248	\$	7,675	
Trucks, medium	4,161	490,970	43	28,200	519,170	0.002382	\$	1,237	
Trucks, heavy	2,263	432,729	6	6,345	439,074	0.001619	\$	711	
Trucks, semi-trailer	2,592	656,125	43	60,348	716,473	0.001543	\$	1,105	
Trucks, full-trailer	1,241	487,163	17	35,532	522,695	0.001396	\$	730	
Busses	1,460	225,350	44	36,801	262,151	0.001873	\$	491	
Total trucks & busses	52,889	4,601,276	329	221,229	4,822,505			\$	11,949
Total all vehicles	103,733	5,909,238	2,190	483,771	6,393,009			\$	15,349

Total Annual Income.....

\$15,349

Diverted Traffic
@ 100%

	New	Old	New	Old
<u>Trucks, Medium</u>				
Average speed (miles per hour)...	30.8	26.7		
Distance (miles).....	27.75	28.55		
Time (hours per trip).....	0.901	1.069		
Time savings per vehicle.....	0.168			
Value of savings (\$/vehicle-hour)	\$1.17			
Annual traffic volume.....	4,161			
Total.....	\$ 818		\$85	
<u>Trucks, Heavy</u>				
Average speed (miles per hour)...	27.8	23.7		
Distance (miles).....	27.75	28.55		
Time (hours per trip).....	0.998	1.205		
Time savings per vehicle.....	0.207			
Value of savings (\$/vehicle-hour)	\$1.47			
Annual traffic volume.....	7,556			
Total.....	\$ 2,299		\$298	
Total...each category.....	\$ 11,273		\$2,168	
TOTAL ANNUAL TIME ELEMENT SAVINGS.....		\$13,441		

e. Mileage Element Savings
Tabulation as follows:

HIGHWAY PROJECT ANALYSIS

Mileage Element Savings

Location of project		MONTANA		County		CARTER	
Description of Project		EKALAKA-ALZADA					
Highway number		FAS No. 323 & FA No. 23		Highway system		FA SECONDARY & FA PRIMARY	
Length		94.0 Miles		Date of Analysis		MARCH 1946	
		Local Traffic				Diverted Traffic	
						@ 100%	
Distance		New		Old		New	
						Old	
Length (miles).....		27.75		28.55			
Distance saving (miles).....		0.8					
Average annual traffic (tons).....		344,562					
Annual traffic saving (ton-mi.)...		275,650					
Cost (\$/ton-mile).....		\$0.0178					
Total.....		\$ 4,906				\$5,800	
Surface							
Roadway surface type.....		0.147		0.220			
Saving coefficient.....		0.073					
Aver. annual traffic (ton-mi.)....		9,837,245					
Saving (\$/ton-mile).....		\$0.0013					
Total.....		\$12,788				\$47	
Alignment							
Curvature rating.....		7.0		3.5			
Points improvement.....		3.5					
Saving (point-ton-miles).....		34,430,358					
Saving (\$/point-ton-mile).....		\$0.0001					
Total.....		\$ 3,443				\$70	
Total.....each category.....		\$ 21,137				\$5,917	
TOTAL ANNUAL MILEAGE ELEMENT SAVINGS.....						\$ 27,054	

f. Traffic Benefits
Tabulation as follows:

HIGHWAY PROJECT ANALYSIS

Location of project	MONTANA	County	CARTER
Description of project	EKALAKA-ALZADA		
Highway number	FAS No. 323 & FA No. 23	Highway System	FA SECONDARY & FA PRIMARY
Length	94.0 Miles	Date of Analysis	MARCH 1946

Mileage Element Factors

Item		Fuel Function	Non-fuel Function
Distance savings	\$10,706 38%	\$ 4,068	\$ 6,638
Roadway surface savings	12,835 50.5%	6,482	6,353
Alignment savings	3,513 50%	1,756	1,757
Total Mileage Savings	\$27,054	\$ 12,306	\$ 14,748

Time Element Factors

Type of Traffic	Annual Value of Time Savings
Passenger cars	\$ 5,004
Trucks, light	4,937
Trucks, medium	903
Trucks, heavy	2,597
Total Time Savings	13,441

Recapitulation of Annual Benefits

Total Fuel Function Benefits	\$ 12,306
Non-fuel Function (Mileage element factors	\$ 14,748
Benefits (Time element factors	\$ 13,441
Total Non-fuel Function Benefits	\$ 28,189
TOTAL ANNUAL BENEFITS	\$ 40,495

g. Derivation of Quotients
Tabulation as follows:

HIGHWAY PROJECT ANALYSIS

Location of project	MONTANA	County	CARTER
Description of project	EKALAKA-ALZADA		
Highway number	FAS No. 323 & FA No. 23	Highway System	FA SECONDARY & FA PRIMARY
Length	94.0 Miles	Date of Analysis	MARCH 1946

Iar = \$	15,349	K ₁	= 1.00
C _a = \$	68,318	K ₂	= 2,263/12,306 = 0.185

(Derivation of Quotients cont'd)

$$\begin{aligned}
B_n &= \$ 28,189 & K_3 &= 0.05/0.20 = 0.25 \\
B_f &= \$ 12,306 & K_2K_3 &= 0.185 \times 0.25 = 0.045 \\
K_1C_a &= \$ 68,318 & 1-K_2K_3 &= 1.00 - 0.045 = 0.955 \\
Q_s &= I_{ar}/K_1C_a = 15,349/68,318 = 0.225 \\
Q_{Bn} &= B_n/K_1C_a = 28,189/68,318 = 0.415 \\
Q_{Bf} &= B_f/K_1C_a = 12,306/68,318 = 0.18 \\
Q's &= Q_s - K_2K_3Q_{Bf} = 0.225 - 0.045 \times 0.18 = 0.225 - 0.01 = 0.215 \\
Q_c &= 0.707(Q_s/Q_{Bn} \cdot Q_{Bf}(1-K_2K_3)) = 0.707(0.225 / 0.415 \cdot 0.18 \times 0.955) \\
&= 0.707(0.225 / 0.415 \cdot 0.17) \\
&= 0.707 \times 0.81 \\
&= 0.57
\end{aligned}$$

Note the small value of the composite quotient which comes about by reason of high construction costs along with the accumulation of generally small benefit values.

B. EKALAKA-ALZADA; Federal Aid Secondary, 80.5 miles via Sykes Bridge, Capitol and Albion. This routing has its advantages insofar as road service is concerned because it taps the populous areas of Carter County along the Little Missouri River and affords a convenient outlet to Camp Crook, South Dakota, which is a trading center for the "plains" area in that vicinity. The principal drawback to designating the routing as a part of the secondary system is the fact that the road ranges so far east of an equally populous area between Belltower and Ridgeway. Three analyses will be presented herewith to show the routing in terms of its economic worth.

1. EKALAKA-SYKES BRIDGE; Oiled Surface, 18.5 miles.

a. Annual Cost Calculations

Annual Capital costs for this section of the Ekalaka-Capitol-Albion-Alzada routing will be identical to those listed in Analysis A, sub-section 1, a, that is, \$15,984 to include interest payments and maintenance charges.

b. Average Daily Traffic, 1960.

Traffic values, local and diverted will be the same as those listed in Analysis A, sub-section 1, b.

c. Annual Revenues

These values will be the same as those listed in Analysis A sub-section 1, c.

d. Time Element Savings

These values are somewhat less in the aggregate than those set forth in Analysis A, sub-section 1, d, although those benefits which will develop in the interest of diverted traffic are about \$200 in excess of those cited in the first instance. This comes about by reason of the fact that the Ekalaka-Sykes Bridge section of the route comprises 23% of the whole in this case and 19.7% in the first instance, (Analysis A, sub-section 1, d). With respect to the local traffic we find that the route length is shorter by 13.5 miles, (94.0 - 80.5) hence the trip distance for each vehicle considered in the analysis is proportionately shorter. Accordingly we find lesser individual distance savings in each case along with lesser values of travel distance both "old" and "new", the time consuming variables in each equation. These particular variables when taken in combination with a constant traffic value produce lesser values in time savings as shown in the tabulation which follows hereinafter.

HIGHWAY PROJECT ANALYSIS

Location of project		Time Element Savings	
MONTANA		CARTER	
Description of project		County	
EKALAKA-SYKES BRIDGE		CARTER	
Highway number		Highway system	
FAS No. 323		FA SECONDARY	
Length		Date of analysis	
18.5 Miles		MARCH 1946	
		Local Traffic	
		Diverted Traffic	
Annual Traffic Volume		New	Old
Private Passenger cars (per year)		31,755	1,861
Trucks, light (per year).....		25,550	176
Trucks, medium (per year).....		2,591	43
Trucks, heavy (per year).....		4,709	110
Totals.....		64,605	2,190
Private Passenger Cars		New	Old
Average speed (miles per hour)...		36.9	32.8
Distance (Miles).....		21.0	21.35
Time (hours per trip).....		0.569	0.651
Time savings per vehicle.....		0.082	1.723
Value of savings (\$/vehicle-hour)		\$0.60	\$0.60
Annual traffic volume.....		31,755	1,861
Value of time savings.....		\$1,924	\$1,924
Totals.....		\$ 1,562	\$443, 23%
Trucks, Light		New	Old
Average speed (miles per hour)...		33.9	29.8
Distance (miles).....		21.0	21.35
Time (hours per trip).....		0.619	0.716
Time savings per vehicle.....		0.097	1.757
Value of savings (\$/vehicle-hour)		\$0.86	\$0.86
Annual traffic volume.....		25,550	176
Value of time savings.....		\$266	\$266
Totals.....		\$ 2,131	\$61, 23%
Trucks, Medium		New	Old
Average speed (miles per hour)...		29.9	25.8
Distance (miles).....		21.0	21.35
Time (hours per trip).....		0.702	0.828
Time savings per vehicle.....		0.126	2.073
Value of savings (\$/vehicle-hour)		\$1.17	\$1.17

	(Time Element Savings cont'd)			
	New	Old	New	Old
<u>Trucks, Medium(cont'd)</u>				
Annual traffic volume.....	2,591		43	
Value of time savings.....			\$131	
Total.....	\$ 382		\$30, 23%	
<u>Trucks, Heavy</u>				
Average speed (miles per hour)...	26.9	22.8	31.5	31.5
Distance (miles).....	21.0	21.35	155.5	227.0
Time (hours per trip).....	0.780	0.936	4.936	7.206
Time savings per vehicle.....	0.156		2.270	
Value of savings (\$/vehicle-hour)	\$1.47		\$1.47	
Annual traffic volume.....	4,709		110	
Value of time savings.....			\$367	
Total.....	\$ 1,080		\$84, 23.0%	
Total.....each category.....	\$ 5,155		\$618	
TOTAL ANNUAL TIME ELEMENT SAVINGS.....	\$ 5,773			

c. Mileage Element Savings

As brought out in the next preceding discussion these values are somewhat less than those cited in Analysis A sub-section 1, e, by reason of lesser trip distance savings in connection with local traffic. In regard to the diverted traffic we find as set forth in the discussion sub-section d, Time Element Savings, that these values are considerably higher by reason of the fact that the Ekalaka-Sykes Bridge section comprises a larger proportion of the route length as a whole.

HIGHWAY PROJECT ANALYSIS

		Mileage Element Savings	
Location of project	MONTANA	County	CARTER
Description of Project	EKALAKA - SYKES BRIDGE		
Highway number	FAS No. 323	Highway system	FA SECONDARY
Length	18.5 Miles	Date of analysis	MARCH 1946
		Local Traffic	Diverted Traffic

Distance	New	Old	New	Old
Length (miles).....	21.0	21.35	155.5	227.0
Distance saving (miles).....	0.35		71.5	
Average annual traffic (tons)....	214,355		5,146	
Annual traffic saving (ton-mi.)..	75,024		367,939	
Cost (\$/ton-mile).....	\$0.0178		\$0.0196	
Annual saving.....			\$7,212	
Total.....	\$ 1,335		\$1,659, 23%	

Surface				
Roadway surface type.....	0.16	0.25	0.075	0.077
Saving coefficient.....	0.09		0.002	
Aver. annual traffic (ton-mi.)..	4,576,479		1,168,142	
Saving (\$/ton-mile).....	\$0.0016		\$0.00004	
Annual Saving.....			\$47	
Total.....	\$ 7,322		\$11, 23%	

Mileage Element Savings (cont'd)

Alignment	New	Old	New	Old
Curvature rating.....	5.3	3.5	10	9.4
Points improvement.....	1.8		0.6	
Saving (point-ton-miles).....	8,237,662		700,885	
Saving (\$/point-ton-mile).....	\$0.0001		\$0.0001	
Annual saving.....			\$70	
Total.....	\$ 824		\$16,23%	
Total....each category.....	\$ 9,481		\$ 1,686	

TOTAL ANNUAL MILEAGE ELEMENT SAVINGS.....\$ 11,167

f. Traffic Benefits
Tabulation as follows:

HIGHWAY PROJECT ANALYSIS

Location of project	MONTANA	County	TRAFFIC BENEFITS
Description of project	EKALAKA-SYKES BRIDGE		
Highway number	FAS No. 323	Highway system	FA SECONDARY
Length	18.5 Miles	Date of Analysis	MARCH 1946

Mileage Element Factors

Item		Fuel Function	Non-fuel Function
Distance savings	\$2,994 38%	\$ 1,138	\$ 1,856
Roadway surface savings	7,333 42.5%	3,117	4,216
Alignment savings	840 50%	420	420
Total Mileage Savings	\$11,167	\$ 4,675	\$ 6,492

Time Element Factors

Type of Traffic	Annual Value of Time Savings
Passenger cars	\$ 2,005
Trucks, light	\$ 2,192
Trucks, medium	\$ 412
Trucks, heavy	\$ 1,164
Total Time Savings	\$ 5,773

Recapitulation of Annual Benefits

Total Fuel Function Benefits	\$ 4,675
Non-fuel function benefits	(Mileage element factors \$ 6,492 (Time element factors \$ 5,773)
Total Non-fuel Function Benefits	\$ 12,265
TOTAL ANNUAL BENEFITS	\$ 16,940

g. Derivation of Quotients
Tabulation as follows:

HIGHWAY PROJECT ANALYSIS

Location of project	MONTANA	County	CARTER
Description of project	EKALAKA-SYKES BRIDGE		
Highway number	FAS No. 323	Highway System	FA SECONDARY
Length	18.5 Miles	Date of analysis	MARCH 1946

$$I_{ar} = \$ 5,966 \quad K_1 = 1.00$$

$$C_a = \$ 15,984 \quad K_2 = 643/4,675 = 0.14$$

$$B_n = \$ 12,265 \quad K_3 = 0.05/0.20 = 0.25$$

$$B_f = \$ 4,675 \quad K_2 K_3 = 0.14 \times 0.25 = 0.035$$

$$K_1 C_a = \$ 15,984 \quad 1 - K_2 K_3 = 1.00 - 0.035 = 0.965$$

$$Q_s = I_{ar} / K_1 C_a = 5,966 / 15,984 = 0.375$$

$$Q_{Bn} = B_n / K_1 C_a = 12,265 / 15,984 = 0.765$$

$$Q_{Bf} = B_f / K_1 C_a = 4,675 / 15,984 = 0.29$$

$$Q'_s = Q_s - K_2 K_3 Q_{Bf} = 0.375 - 0.035 \times 0.29 = 0.375 - 0.01 = 0.365$$

$$Q_c = 0.707 (Q_s / Q_{Bn} / Q_{Bf} (1 - K_2 K_3)) = 0.707 (0.375 / 0.765 / 0.29 \times 0.965)$$

$$= 0.707 (0.375 / 0.765 / 0.28)$$

$$= 0.707 \times 1.42$$

$$= 1.00$$

On reference to the tabulation we find the composite solvency quotient to be unity, 0.06 less than that value which was computed in Analysis A, sub-section 1, g. This by reason of lesser Time Element Savings and Mileage Element Savings, the income and cost factors being equivalent in both instances.

2. EKALAKA-ALBION: Oiled Surface, 18.5 miles; Gravel Surface, 47.5 miles; total travel-distance 66.0 miles.

a. Annual Cost Calculations

Since the traffic volume between Sykes Bridge and Albion will be less than 100 vehicles per day per mile, this section will be built to gravel surface standards. (See page iv of the Prefatory Assembly).

Estimated construction costs are as follows:

Re-grading, 9.5 miles @ \$1,500 per mile..... \$14,250

Grading, 56.5 miles @ \$4,000 per mile.....\$226,000

Gravel Base and Surface, 66.0 miles @ \$3,500.....	\$231,000
Major Drainage Structures, bridges	
2 Steel, 250 feet @ \$150 per lineal foot.....	\$37,500
9 Timber, 540 feet @ \$100 per lineal foot.....	\$54,000
Minor Drainage Structures, 56.5 miles @ \$800 per mile.....	\$45,200
Oiled Surface, 18.5 miles @ \$2,000 per mile.....	\$37,000
Rights-of-Way	
9 miles @ \$500 per mile.....	\$4,500
47.5 miles @ \$400 per mile.....	\$19,000
Engineering and Administration	
Grading, gravel and oil 9.0 miles @ \$1,000 per mile.....	\$9,000
Re-gravel and oil 9.5 miles @ \$600 per mile.....	\$5,700
Grade and gravel 47.5 miles @ \$800 per mile.....	\$38,000
Bridges, 5% of \$91,500.....	\$4,575
Sub-total.....	\$725,725
✓ 10% for contingencies.....	\$72,573
Total construction costs 66.0 miles.....	\$798,298

These data are summarized and extended in the tabulation which follows to arrive at an annual capital cost.

ANNUAL COST CALCULATIONS

Location of project	MONTANA	County	CARTER
Description of project	EKALAKA-ALBION		
Highway number	FAS No. 323.	Highway System	FA SECONDARY
Length	66.0 Miles	Date of Analysis	MARCH 1946

Item	CAPITAL COSTS			Annual Capital Cost
	Net Cost	Interest Rate	Amort. Period	
Rights of way, easements, etc.	\$ 23,500	2½%	20 years	\$ 1,506
Clearing, grading, etc.	240,250	"	"	15,400
Pavements and surfacing:				
Type Gravel	231,000	"	"	14,807
Type Oil	37,000	"	"	2,372
Structures:				
Type Major, 2 Steel	37,500	"	"	2,404
Type Major, 9 Timber	54,000	"	"	3,461
Type Minor	45,200	"	"	2,897
Engineering & Administration..	57,275	"	"	3,671
✓ 10% for contingencies.....	72,573	"	"	4,652
1. Total annual capital cost.....				\$ 51,170
2. Total annual maintenance cost	66 miles @ \$100.00			\$ 6,600
TOTAL ANNUAL COSTS (1 ✓ 2)				\$ 57,770

b. Average Daily Traffic, 1960

(1) Local Traffic

Construction of this section of the Ekalaka-Capitol-Alzada routing will allow interior diversion from the Chalk Buttes road and from the Belltower-Ridgeway-Hammond routing as discussed in Analysis A. Informative data are as shown on page 69.

(2) Diverted Traffic

Traffic values in reference to the diverted traffic will be computed in the proportion that this section bears to the whole of the routing, 82%.

c. Annual Revenues

On the basis of traffic data set forth heretofore the estimated annual income will be as shown on page 70.

d. Time Element Savings

Tabulation as follows:

HIGHWAY PROJECT ANALYSIS

Time Element Savings

Location of project	MONTANA	County	CARTER	
Description of project	EKALAKA-ALBION			
Highway number	FAS No. 323	Highway System	FA SECONDARY	
Length	66.0 Miles	Date of Analysis	MARCH 1946	
	Local Traffic	Diverted Traffic @ 82%		
Annual Traffic Volume	New	Old	New	Old
Private Passenger cars (per year)	61,539		1,861	
Trucks, light (per year).....	49,823		176	
Trucks, medium (per year).....	5,037		43	
Trucks, heavy (per year).....	9,161		110	
Totals.....	125,560		2,190	
Private Passenger Cars				
Average speed (miles per hour)...	35.7	31.5		
Distance (Miles).....	21.6	22.55		
Time (hours per trip).....	0.605	0.716		
Time savings per vehicle.....	0.111			
Value of savings (\$/vehicle-hour)	\$0.60			
Annual traffic volume.....	61,539			
Totals.....	\$ 4,098		\$1,578	
Trucks, Light				
Average speed (miles per hour)...	32.7	28.7		
Distance (miles).....	21.6	22.55		
Time (hours per trip).....	0.660	0.786		
Time savings per vehicle.....	0.126			
Value of savings (\$/vehicle-hour)	\$0.86			
Annual traffic volume.....	49,823			
Totals.....	\$ 5,399		\$218	

(cont'd on page 71)

LOCAL TRAFFIC WITH TRAVEL-DISTANCE DATA AS OF
COMPLETION OF THE EKALAKA-ALBION SECTION
OF THE EKALAKA-CAPITOL-ALZADA ROUTING

[illegible]

HIGHWAY PROJECT ANALYSIS

Traffic Income

Location of project Montana Description of project Ekalaka - Albion County Carter
 Highway FAS #323 Highway System FA Secondary Length 66.0 miles Date of analysis March 1946

Traffic Type	Average Annual Traffic				Average Annual		Unit Net	Total Annual
	Local Traffic		Diverted Traffic		Road Use During		Revenues	Net Revenue
	Vehicles	Ton	Vehicles	Ton	Life of Project		Per Ton Mi.	
	: Miles	:	: Miles	:	Ton Miles		:	:
Passenger Cars-Montana	: 59,020	: 1,051,596:	: 1,588	: 157,335	: 1,208,931	: \$0.002188	:	\$ 2,645
Passenger Cars-Foreign	: 2,519	: 44,203:	: 273	: 27,030	: 71,233	: 0.001799	:	128
Total passenger cars	: 61,539	: 1,095,799:	: 1,861	: 184,365	: 1,280,164	:	:	\$ 2,773
Trucks, light	: 49,823	: 1,906,199:	: 176	: 37,923	: 1,944,122	: 0.003248	:	\$ 6,315
Trucks, medium	: 5,037	: 405,464:	: 43	: 19,803	: 425,267	: 0.002382	:	\$ 1,013
Trucks, heavy	: 2,774	: 361,881:	: 6	: 4,455	: 366,336	: 0.001619	:	\$ 593
Trucks, semi-trailer	: 3,139	: 542,084:	: 43	: 42,378	: 584,462	: 0.001543	:	\$ 902
Trucks, full-trailer	: 1,496	: 400,643:	: 17	: 24,953	: 425,596	: 0.001396	:	\$ 594
Busses	: 1,752	: 184,486:	: 44	: 25,843	: 210,329	: 0.001873	:	\$ 394
Total trucks & busses	: 64,021	: 3,800,757:	: 329	: 155,355	: 3,956,112	:	:	\$ 9,811
Total all vehicles	: 125,560	: 4,896,556:	: 2,190	: 339,720	: 5,236,276	:	:	\$12,584

Total Annual Income.....

\$12,584

(Time Element Savings cont'd)

	Local Traffic		Diverted Traffic @ 82%	
	New	Old	New	Old
Trucks, Medium				
Average speed (miles per hour)....	28.7	24.7		
Distance (miles).....	21.6	22.55		
Time (hours per trip).....	0.753	0.913		
Time savings per vehicle.....	0.160			
Value of savings (\$/vehicle-hour).....	\$1.17			
Annual traffic volume.....	5,037			
Total.....	\$ 943		\$ 107	
Trucks, Heavy				
Average speed (miles per hour)....	25.7	21.7		
Distance (miles).....	21.6	22.55		
Time (hours per trip).....	0.840	1.039		
Time savings per vehicle.....	0.199			
Value of savings (\$/vehicle-hour).....	\$1.47			
Annual traffic volume.....	9,161			
Total.....	\$ 2,680		\$ 301	
Total...each category.....	\$13,120		\$2,204	
TOTAL ANNUAL TIME ELEMENT SAVINGS.....			\$ 15,324	

e. Mileage Element Savings
Tabulation as follows:

HIGHWAY PROJECT ANALYSIS

Mileage Element Savings

Location of project	MONTANA	County	CARTER	
Description of Project	EKALAKA-ALBION			
Highway number	FAS No. 323	Highway System	FA SECONDARY	
Length	66.0 Miles	Date of Analysis	MARCH 1946	
	Local Traffic		Diverted Traffic @ 82%	
Distance	New	Old	New	Old
Length (Miles).....	21.6	22.55		
Distance saving (miles).....	0.95			
Average annual traffic (tons).....	418,509			
Annual traffic saving (ton-mi.).....	397,584			
Cost (\$/ton-mile).....	\$0.0178			
Total.....	\$ 7,077		\$ 5,914	
Surface				
Roadway surface type.....	0.19	0.26		
Saving coefficient.....	0.07			
Aver. annual traffic (ton-mi.).....	9,437,378			
Saving (\$/ton-mile).....	0.00125			
Total.....	\$ 11,797		\$39	
Alignment				
Curvature rating.....	5.4	1.8		
Points improvement.....	3.6			
Saving (point-ton-miles).....	33,974,561			
Saving (\$/point-ton-mile).....	\$0.0001			
Total.....	\$ 3,397		\$57	
Total...each category.....	\$22,271		\$ 6,010	
TOTAL ANNUAL MILEAGE ELEMENT SAVINGS.....			\$ 28,281	

f. Traffic Benefits
Tabulation as follows:

HIGHWAY PROJECT ANALYSIS

Traffic Benefits

Location of project	MONTANA	County	CARTER
Description of project	EKALAKA-ALBION		
Highway number	FAS No. 323	Highway System	FA SECONDARY
Length	66.0 Miles	Date of Analysis	MARCH 1946

Mileage Element Factors

Item		Fuel Function	Non-fuel Function
Distance savings	\$12,991 38%	\$ 4,937	\$ 8,054
Roadway surface savings	\$11,836 44%	5,208	6,628
Alignment savings	\$3,454 50%	1,727	1,727
Total Mileage Savings	\$28,281	\$ 11,872	\$ 16,409

Time Element Factors

Type of Traffic	Annual Value of Time Savings
Passenger cars	\$ 5,676
Trucks, light	5,617
Trucks, medium	1,050
Trucks, heavy	2,981
Total Time Savings	\$ 15,324

Recapitulation of Annual Benefits

Total Fuel Function Benefits	\$ 11,872
Non-fuel function benefits	(Mileage element factors \$16,409 (Time element factors \$15,324)
Total Non-fuel Function Benefits	\$ 31,733
TOTAL ANNUAL BENEFITS	\$ 43,605

g. Derivation of Quotients
Tabulation as follows:

HIGHWAY PROJECT ANALYSIS

Location of project	MONTANA	County	CARTER
Description of project	EKALAKA-ALBION		
Highway number	FAS No. 323	Highway System	FA SECONDARY
Length	66.0 Miles	Date of Analysis	MARCH 1946

Iar = \$	12,584	K ₁	= 1.00
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(Derivation of Quotients cont'd)

$$\begin{aligned}
 C_a &= \$ 57,770 & K_2 &= 2,293/11,872 = 0.195 \\
 B_n &= \$ 31,733 & K_3 &= 0.05/0.20 = 0.25 \\
 B_f &= \$ 11,872 & K_2 K_3 &= 0.195 \times 0.25 = 0.05 \\
 K_1 C_a &= \$ 57,770 & 1-K_2 K_3 &= 1.00 - 0.05 = 0.95 \\
 Q_s &= I_{ar}/K_1 C_a = 12,584/57,770 = 0.22 \\
 Q_{Bn} &= B_n/K_1 C_a = 31,733/57,770 = 0.55 \\
 Q_{Bf} &= B_f/K_1 C_a = 11,872/57,770 = 0.205 \\
 Q'_s &= Q_s - K_2 K_3 Q_{Bf} = 0.22 - 0.05 \times 0.205 = 0.22 - 0.01 = 0.21 \\
 Q_c &= 0.707 (Q_s / Q_{Bn} / Q_{Bf}) (1-K_2 K_3) = 0.707 (0.22 / 0.55 / 0.205 \times 0.95) \\
 &= 0.707 (0.22 / 0.55 / 0.195) \\
 &= 0.707 \times 0.965 \\
 &= 0.68
 \end{aligned}$$

Note drop in composite solvency quotients occasioned by decrease in traffic volume (road use) between Sykes Bridge and Albion along with increased bridge construction costs.

3. EKALAKA-ALZADA: Oiled Surface, 33.0 miles; Gravel surface, 47.5 miles; total travel-distance, 80.5 miles.

a. Annual Cost Calculations

In accord with the standards set forth on page iv of the Prefatory Assembly, there will be two sections of this routing built to an oiled surface standard, one being that interval extending from Ekalaka to Sykes Bridge and the other being the Albion-Alzada section. The 47.5 miles extending from Sykes Bridge to Albion will be built to a gravel surface standard.

Details of construction costs are as follows:

Re-grading, 9.5 miles @ \$1,500 per mile.....	\$14,250
Grading, 71.0 miles @ \$4,000 per mile.....	\$284,000
Gravel Base and Surface, 80.5 miles @ \$3,500 per mile.....	\$281,750
Major Drainage Structures, bridges	
2 Steel, 250 feet @ \$150 per lineal foot.....	\$37,500
12 Timber, 720 feet @ \$100 per lineal foot.....	\$72,000
Minor Drainage Structures, 71.0 miles @ \$800 per mile.....	\$56,800
Oiled Surface, 33 miles @ \$12,000 per mile.....	\$66,000

Rights-of-Way,
 23.5 miles @ \$500 per mile..... \$11,750
 47.5 miles @ \$400 per mile..... \$19,000

Engineering and Administration
 Grading, gravel and oil 23.5 miles @ \$1,000 per mile..... \$23,500
 Re-gravel and oil, 9.5 miles @ \$600 per mile..... \$5,700
 Grade and gravel, 47.5 miles @ \$800 per mile..... \$38,000
 Bridges, 5% of \$109,500..... \$5,475

Sub-total.....\$915,725

✓ 10% for contingencies..... \$91,573

Total construction costs, 80.5 miles..... \$1,007,298

ANNUAL COST CALCULATIONS

Location of project	MONTANA	County	CARTER
Description of project	EKALAKA-ALZADA		
Highway number	FAS No. 323	Highway System	FA SECONDARY
Length	80.5 Miles	Date of Analysis	MARCH 1946

	CAPITAL COSTS			Annual
Item	Net Cost	Interest Rate	Amort. Period	Capital Cost
Rights of way, easements, etc.	\$ 30,750	2½%	20 years	\$ 1,971
Clearing, grading, etc.	298,250	"	"	19,118
Pavements and surfacing:				
Type Gravel	281,750	"	"	18,060
Type Oil Surface	66,000	"	"	4,231
Structures:				
Type Major, 2 Steel	37,500	"	"	2,404
Type Major, 12 Timber	72,000	"	"	4,615
Type Minor	56,800	"	"	3,641
Engineering & Administration..	72,675	"	"	4,658
✓ 10% for contingencies.....	91,573	"	"	5,870
1. Total annual capital cost.....				\$ 64,568

2. Total annual maintenance cost 80.5 miles @ \$100.00 \$ 8,050

TOTAL ANNUAL COSTS (1 / 2) \$ 72,618

b. Average Daily Traffic, 1960

(1) Local Traffic

As the routing proceeds south and nears Alzada there is an increasing opportunity for local or interior diversion to the routing from other routes cited herebefore. Details of traffic volume and travel-distance are as shown on page 75.

LOCAL TRAFFIC WITH TRAVEL DISTANCE DATA AS OF
COMPLETION OF THE EKALAKA-SYKES BRIDGE-
CAPITOL-ALZADA ROUTING

	EXISTING FACILITIES (Miles)				NEW FACILITIES (Miles)			
	PTW	APPROACH	TOTAL TRAVEL DISTANCE	NEW	APPROACH	TOTAL TRAVEL DISTANCE		
TRAFFIC								
CLASSIFIC'N	ADT	GRAVEL:UNIMP	OIL : GRAVEL:UNIMP:TOTAL	OIL : GRAVEL: UNIMP	OIL:GRAVEL:UNIMP:TOTAL			
Existing Traffic	394.0	3.4 : 9.4 : 9.05	3.4 : 18.45:21.85	7.5 : 4.5 : 9.05	7.5 : 4.5 : 9.05	21.05		
Diverted Traffic	55.5	11.5 : 1.9 : 2.05	13.55:15.45	2.25: 9.75 : 3.0	2.25: 9.75 : 3.0	15.0		
Local Traffic	149.5	3.0 : 9.65: 0.25	8.2 : 17.85:21.1	6.85: 5.15 : 8.3	6.85: 5.15 : 8.3	20.3		

(2) Diverted Traffic

Six vehicles per day per mile will be effective over 100% of the routing.

c. Annual Revenues

Income to be expected on completion of the routing is as shown on page 77.

d. Time Element Savings

Per tabulation which follows:

HIGHWAY PROJECT ANALYSIS

Location of project		Time Element Savings	
MONTANA		CARTER	
Description of project		Ekalaka-Alzada	
Highway number		FA SECONDARY	
Length		MARCH 1946	
80.5 Miles		Date of Analysis	
		Local Traffic	Diverted Traffic
Annual Traffic Volume		New	Old
Private Passenger cars (per year)		80,410	
Trucks, light (per year).....		65,116	
Trucks, medium (per year).....		6,570	
Trucks, heavy (per year).....		11,973	
Totals.....		164,069	
Private Passenger Cars		New	Old
Average speed (miles per hour)...		36.4	31.3
Distance (Miles).....		20.3	21.1
Time (hours per trip).....		0.558	0.674
Time savings per vehicle.....		0.116	
Value of savings(\$/vehicle-hour)...		\$0.60	
Annual traffic volume.....		80,410	
Totals.....		\$ 5,597	\$ 1,924
Trucks, Light		New	Old
Average speed (miles per hour)...		33.4	28.3
Distance (miles).....		20.3	21.1
Time (hours per trip).....		0.608	0.746
Time savings per vehicle.....		0.138	
Value of savings (\$/vehicle-hour)		\$0.86	
Annual traffic volume.....		65,116	
Totals.....		\$ 7,728	\$266
Trucks, Medium		New	Old
Average speed (miles per hour)...		29.4	24.3
Distance (miles).....		20.3	21.1
Time (hours per trip).....		0.690	0.868
Time savings per vehicle.....		0.178	
Value of savings (\$/vehicle-hour)		\$1.17	
Annual traffic volume.....		6,570	
Totals.....		\$ 1,368	\$131
Trucks, Heavy		New	Old
Average speed (miles per hour)...		26.4	21.3
Distance (miles).....		20.3	21.1

HIGHWAY PROJECT ANALYSIS

Traffic Income

Location of project Montana Description of project Ekalaka - Alzada County Carter
 Highway FAS No. 323 Highway System FA Secondary Length 80.5 miles Date of analysis March 1946

Traffic Type	Average Annual Traffic						Average Annual			Unit Net	Total Annual
	Local Traffic			Diverted Traffic			Road Use During			Revenues	Net Revenue
	Vehicles	Ton	Miles	Vehicles	Ton	Miles	Life of Project			Per Ton Mi.	
							Ton Miles				
Passenger Cars - Montana	77,125	1,388,244		1,588	224,049		1,612,293	\$0.002188		\$ 3,528	
Passenger Cars - Foreign	3,285	59,136		273	38,493		97,629	0.001799		176	
Total passenger cars	80,410	1,447,380		1,861	262,542		1,709,922			\$ 3,704	
Trucks, light	65,116	2,555,148		176	54,003		2,609,151	0.003248		\$ 8,475	
Trucks, medium	6,570	542,424		43	28,200		570,624	0.002382		\$ 1,359	
Trucks, heavy	3,614	483,552		6	6,345		489,897	0.001619		\$ 793	
Trucks, semi-trailer	4,088	724,068		43	60,348		784,416	0.001543		\$ 1,210	
Trucks, full-trailer	1,971	541,392		17	35,532		576,924	0.001396		805	
Busses	2,300	248,400		44	36,801		285,201	0.001873		534	
Total trucks & busses	83,659	5,094,984		329	221,229		5,316,213			\$13,176	
Total all vehicles	164,069	6,542,364		2,190	483,771		7,026,135			\$16,880	

Total Annual Income..... \$16,880

	(Time Element Savings cont'd)			
	Local Traffic		Diverted Traffic	
	New	Old	New	Old
Time (hours per trip).....	0.769	0.991		
Time savings per vehicle.....	0.222			
Value of savings (\$/vehicle-hour).....	\$1.47			
Annual traffic volume.....	11,973			
Total.....	\$ 3,907		\$367	
Total...each category.....	\$ 18,600		\$2,688	
TOTAL ANNUAL TIME ELEMENT SAVINGS.....			\$ 21,288	

e. Mileage Element Savings
Per tabulation which follows:

HIGHWAY PROJECT ANALYSIS

Mileage Element Savings

Location of project	MONTANA	County	CARTER
Description of Project	EKALAKA-ALZADA		
Highway number	FAS No. 323	Highway System	FA SECONDARY
Length	80.5 Miles	Date of Analysis	MARCH 1946

	Local Traffic		Diverted Traffic	
	New	Old	New	Old
Distance				
Length (miles).....	20.3	21.1		
Distance saving (miles).....	0.8			
Average annual traffic (tons).....	545,197			
Annual traffic saving (ton-mi.).....	436,158			
Cost (\$/ton-mile).....	\$0.0178			
Total.....	\$ 7,764		\$ 7,212	

Surface				
Roadway surface type.....	0.17	0.26		
Saving coefficient.....	0.09			
Aver. annual traffic (ton-mi.).....	11,067,499			
Saving (\$/ton-mile).....	\$0.0016			
Total.....	\$ 17,708		\$47	

Alignment				
Curvature rating.....	5.9	1.5		
Points improvement.....	4.4			
Saving (point-ton-miles).....	48,696,996			
Saving (\$/point-ton-mile).....	\$0.0001			
Totals.....	\$ 4,870		\$70	
Total....each category.....	\$ 30,342		\$7,329	

TOTAL ANNUAL MILEAGE ELEMENT SAVINGS.....\$ 37,671

f. Traffic Benefits
Per tabulation which follows:

HIGHWAY PROJECT ANALYSIS

Traffic Benefits

Location of project MONTANA County CARTER
 Description of project EKALAKA-ALZADA
 Highway number FAS No. 323 Highway System FA SECONDARY
 Length 80.5 Miles Date of Analysis MARCH 1946

Mileage Element Factors

Item			Fuel Function	Non-fuel Function
Distance savings	\$14,976	38%	\$ 5,691	\$ 9,285
Roadway surface savings	17,755	44.5%	7,901	9,854
Alignment savings	4,940	50%	2,470	2,470
Total Mileage Savings	\$37,671		\$ 16,062	\$ 21,609

Time Element Factors

Type of Traffic	Annual Value of Time Savings
Passenger cars	\$ 7,521
Trucks, light	7,994
Trucks, medium	1,499
Trucks, heavy	4,274
Total Time Savings	\$ 21,288

Recapitulation of Annual Benefits

Total Fuel Function Benefits	\$ 16,062
Non-fuel function (Mileage element factors	\$ 21,609
benefits (Time element factors	\$ 21,288
Total Non-fuel Function Benefits	\$ 42,897
TOTAL ANNUAL BENEFITS	\$ 58,959

g. Derivation of Quotients
 Per tabulation which follows:

HIGHWAY PROJECT ANALYSIS

Location of project MONTANA County CARTER
 Description of project EKALAKA-ALZADA
 Highway number FAS No. 323 Highway System FA SECONDARY
 Length 80.5 Miles Date of Analysis March 1946

Iar = \$ 16,880	K ₁	= 1.00
C _a = \$ 72,618	K ₂	= 2,796/16,062 = 0.175

(Derivation of Quotients cont'd)

$$\begin{aligned} B_n &= \$ 42,897 & K_3 &= 0.05/0.20 = 0.25 \\ B_f &= \$ 16,062 & K_2 K_3 &= 0.175 \times 0.25 = 0.045 \\ K_1 C_a &= \$ 72,618 & 1 - K_2 K_3 &= 1.00 - 0.045 = 0.955 \\ Q_s &= I_{ar}/K_1 C_a = 16,880/72,618 = 0.23 \\ Q_{Bn} &= B_n/K_1 C_a = 42,897/72,618 = 0.59 \\ Q_{Bf} &= B_f/K_1 C_a = 16,062/72,618 = 0.22 \\ Q'_s &= Q_s - K_2 K_3 Q_{Bf} = 0.23 - 0.045 \times 0.22 = 0.23 - 0.01 = 0.22 \\ Q_c &= 0.707 (Q_s/Q_{Bn}/Q_{Bf}(1 - K_2 K_3)) = 0.707 (0.23 / 0.59 / 0.22 \times 0.955) \\ &= 0.707 (0.23 / 0.59 / 0.21) \\ &= 0.707 \times 1.03 \\ &= 0.73 \end{aligned}$$

Here we see the combined effect of comparatively high traffic volumes on the extremities of the routing to render a composite solvency quotient some 26% in excess of that computed for the Ekalaka-Alzada routing in Analysis A, (0.83 as compared to 0.57). It is, of course, obvious that this latter routing is the preferred choice as far as we now have gone in this report.

C. EKALAKA-ALZADA; Federal Aid Secondary 76.5 miles via Sykes Bridge, Ridgeway and Albion. As is shown in the SUMMARY OF FINDINGS, this routing of all those under study is the preferred location by reason of its high service value to the Carter County road users.

1. EKALAKA-SYKES BRIDGE; Oiled Surface, 18.5 miles.

a. Annual Cost Calculations

Identical with those costs set forth in Analysis A, sub-section 1, a.

b. Average Daily Traffic, 1960

(1) Local Traffic

Average daily traffic and travel-distance data are as shown on page 81.

(2) Diverted Traffic

This element of traffic, 6 vehicles per day will be effective over 24.2% of the length of the whole routing.

c. Annual Revenues

Identical in amount with income values developed in Analysis A, sub-section 1, c.

TRAFFIC CLASSIFICATION	ADT	EXISTING FACILITIES (Miles)				NEW FACILITIES (Miles)				
		PTW		Total Travel Distance		New		Approach: Total Travel Distance		
		GRAVEL:UNIMP:	OIL :UNIMP:	OIL :GRAVEL:	UNIMP:TOTAL:	OIL :GRAVEL:	UNIMP:TOTAL:	OIL :GRAVEL:	UNIMP:TOTAL:	
Existing Traffic	174	7.7	8.05	8.65	7.7	16.7	24.4	11.1	12.75	23.85
Diverted Traffic	3	27.85	0.45	5.4	0.45	33.25	33.70	11.1	0.45	32.35
Local Traffic	177	7.55	8.4	0.05	8.6	7.55	17.0	24.6	0.05	24.05

d. Time Element Savings

Those benefits accruing to the diverted traffic along with a lesser increment of savings for the local traffic illustrate the high service value of the routing. Tabulation of benefits is as follows:

HIGHWAY PROJECT ANALYSIS

Time Element Savings

Location of project	MONTANA	County	CARTER		
Description of project	EKALAKA-SYKES BRIDGE				
Highway number	FAS No. 323	Highway System	FA SECONDARY		
Length	18.5 Miles	Date of Analysis	April 1946		
		Local Traffic	Diverted Traffic		
Annual Traffic Volume		New	Old	New	Old
Private Passenger cars (per year)		31,755		1,861	
Trucks, light (per year).....		25,550		176	
Trucks, medium (per year).....		2,591		43	
Trucks, heavy (per year).....		4,709		110	
Totals.....		64,605		2,190	
Private Passenger Cars					
Average speed (miles per hour)...		36.0	32.5	41.6	41.5
Distance (Miles).....		24.05	24.6	151.5	22.70
Time (hours per trip).....		0.668	0.757	3.642	5.469
Time savings per vehicle.....		0.089		1.827	
Value of savings (\$/vehicle-hour)		\$0.60		\$0.60	
Annual traffic volume.....		31,755		1,861	
Value of time savings.....				\$2,040	
Totals.....		\$ 1,696		\$494, 24.2%	
Trucks, Light					
Average speed (miles per hour)...		33.0	29.5	38.6	38.5
Distance (miles).....		24.05	24.6	151.5	227.0
Time (hours per trip).....		0.730	0.834	3.925	5.896
Time savings per vehicle.....		0.104		1.971	
Value of savings (\$/vehicle-hour)		\$0.86		\$0.86	
Annual traffic volume.....		25,550		176	
Value of time savings.....				\$298	
Totals.....		\$ 2,285		\$72, 24.2%	
Trucks, Medium					
Average speed (miles per hour)...		29.0	25.5	34.6	34.5
Distance (miles).....		24.05	24.6	151.5	227.0
Time (hours per trip).....		0.829	0.965	4.379	6.580
Time savings per vehicle.....		0.136		2.201	
Value of savings (\$/vehicle-hour)		\$1.17		\$1.17	
Annual traffic volume.....		2,591		43	
Value of time savings.....				\$111	
Total.....		\$ 412		\$27, 24.2%	
Trucks, Heavy					
Average speed (miles per hour)...		26.0	22.5	31.6	31.5
Distance (miles).....		24.05	24.6	151.5	227.0
Time (hours per trip).....		0.925	1.093	4.794	7.206
Time savings per vehicle.....		0.168		2.412	
Value of savings (\$/vehicle-hour)		\$1.47		\$1.47	
Annual traffic volume.....		4,709		110	
Value of time savings.....				\$390	
Total.....		\$ 1,163		\$94, 24.2%	
Total...each category.....		\$ 5,556		\$687	
TOTAL ANNUAL TIME ELEMENT SAVINGS.....				\$ 6,243	

e. Mileage Element Savings

Here again the routing shows the highest preferential rating.
Tabulation as follows:

HIGHWAY PROJECT ANALYSIS

Mileage Element Savings

Location of project	MONTANA	County	CARTER
Description of Project	EKALAKA-SYKES BRIDGE		
Highway number	FAS No. 323	Highway System	FA SECONDARY
Length	18.5 Miles	Date of Analysis	APRIL 1946
		Local Traffic	Diverted Traffic

Distance	New	Old	New	Old
Length (miles).....	24.05	24.6	151.5	227.0
Distance saving (miles).....	0.55		75.5	
Average annual traffic (tons)....	214,355		5,146	
Annual traffic saving (ton-mi.)...	117,895		388,523	
Cost (\$/ton-mile).....	\$0.0178		\$0.0196	
Annual saving.....			\$7,615	
Total.....	\$ 2,099		\$1,843	24.2%

Surface

Roadway surface type.....	0.164	0.252	0.075	0.077
Saving coefficient.....	0.088		0.002	
Aver. annual traffic (ton-mi.)....	5,273,133		1,168,142	
Saving (\$/ton-mile).....	\$0.00155		\$0.00004	
Annual saving.....			\$47	
Total.....	\$ 8,173		\$11	24.2%

Alignment

Curvature rating.....	4.6	3.0	10.0	9.4
Points improvement.....	1.6		0.6	
Saving (point-ton-miles).....	8,437,013		700,885	
Saving (\$/point-ton-mile).....	\$0.0001		\$0.0001	
Annual Saving.....			\$70	
Total.....	\$844		\$17	24.2%
Total....each category.....	\$ 11,116		\$1,871	

TOTAL ANNUAL MILEAGE ELEMENT SAVINGS.....\$ 12,987

f. Traffic Benefits

As per tabulation which follows:

HIGHWAY PROJECT ANALYSIS

Traffic Benefits

Location of project	MONTANA	County	CARTER
Description of project	EKALAKA-SYKES BRIDGE		
Highway number	FAS No. 323	Highway system	FA SECONDARY
Length	18.5 Miles	Date of Analysis	APRIL 1946

Mileage Element Factors

Item			Fuel Function	Non-fuel Function
Distance savings	\$3,942	38%	\$ 1,498	\$ 2,444

(Traffic Benefits cont'd)

Item			Fuel Function	Non-fuel Function
Roadway surface savings	\$8,184	42.5%	\$ 3,478	\$ 4,706
Alignment savings	861	50%	431	430
Total Mileage Savings	\$12,987		\$ 5,407	\$ 7,580

Time Element Factors

Type of Traffic	Annual Value of Time Savings
Passenger cars	\$ 2,190
Trucks, light	2,357
Trucks, medium	439
Trucks, heavy	1,257
Total Time Savings	\$ 6,243

Recapitulation of Annual Benefits

Total Fuel Function Benefits	\$ 5,407
Non-fuel function(Mileage element factors	\$ 7,580
benefits (Time element factors	\$ 6,243
Total Non-fuel Function Benefits	\$ 13,823
TOTAL ANNUAL BENEFITS	\$ 19,230

g. Derivation of Quotients

As per tabulation which follows:

HIGHWAY PROJECT ANALYSIS

Location of project	MONTANA	County	CARTER
Description of project	EKALAKA-SYKES BRIDGE		
Highway number	FAS No. 323	Highway System	FA SECONDARY
Length	18.5 Miles	Date of Analysis	APRIL 1946
$I_{ar} = \$$	5,966	K_1	$= 1.00$
$C_a = \$$	15,984	K_2	$= 714/5,407 = 0.13$
$B_n = \$$	13,823	K_3	$= 0.05/0.20 = 0.25$
$B_f = \$$	5,407	$K_2 K_3$	$= 0.13 \times 0.25 = 0.03$
$K_1 C_a = \$$	15,984	$1 - K_2 K_3$	$= 1.00 - 0.03 = 0.97$
$Q_s = I_{ar}/K_1 C_a =$	$5,966/15,984 = 0.375$		
$Q_{B_n} = B_n/K_1 C_a =$	$13,823/15,984 = 0.865$		
$Q_{B_f} = B_f/K_1 C_a =$	$5,407/15,984 = 0.34$		

(Derivation of Quotients cont'd)

$$Q's = Q_s - K_2 K_3 Q_{Bf} = 0.375 - 0.03 \times 0.34 = 0.375 - 0.005 = 0.37$$

$$Q_c = 0.707 (Q_s / Q_{Bn} / Q_{Bf} (1 - K_2 K_3)) = 0.707 (0.375 / 0.865 / 0.34 \times 0.97)$$

$$= 0.707 (0.375 / 0.865 / 0.33)$$

$$= 0.707 \times 1.57$$

$$= 1.11$$

The data set forth hereinabove gives indication of the service value of the routing as a whole and in particular reference to the Ekalaka-Sykes Bridge section.

2. EKALAKA-RIDGEWAY: Oiled Surface, 18.5 miles; Gravel Surface, 16.5 miles; total length, 35.0 miles.

a. Annual Cost Calculations

Identical with those shown in Analysis A, sub-section 2, a.

b. Average Daily Traffic, 1960

(1) Local Traffic

Average daily traffic and travel-distance data are as shown on page 86.

(2) Diverted Traffic

Diverted traffic, 6 vehicles per day per mile will be effective over 45.8% of the total length of the routing.

c. Annual Revenues

As set forth in tabulation on page 87.

d. Time Element Savings

As per tabulation set forth herebelow.

HIGHWAY PROJECT ANALYSIS

Time Element Savings

Location of project	MONTANA	County	CARTER
Description of project	EKALAKA-RIDGEWAY		
Highway number	FAS No. 323	Highway System	FA SECONDARY
Length	35.0 Miles	Date of Analysis	APRIL 1946
		Local Traffic	Diverted Traffic @ 45.8%

Annual Traffic Volume	New	Old	New	Old
Private Passenger cars(per year)	39,164			
Trucks, light (per year).....	31,719			
Trucks, medium (per year).....	3,212			
Trucks, heavy (per year).....	5,840			
Totals.....	79,935			
Private Passenger Cars				
Average speed (miles per hour).. -85-	35.4	31.8		

(cont'd on page 88)

LOCAL TRAFFIC AND TRAVEL-DISTANCE DATA AS OF
COMPLETION OF THE EKALAKA-RIDGEMAY SECTION OF
THE EKALAKA-RIDGEMAY-ALBION-ALZADA ROUTING

TRAFFIC CLASSIFICATION	EXISTING FACILITIES (Miles)				NEW FACILITIES (Miles)			
	ADT	GRAVEL:UNIMP:	UNIMP:	OIL : GRAVEL: TOTAL TRAVEL-DISTANCE	NEW	UNIMP	OIL : GRAVEL: TOTAL TRAVEL-DISTANCE	
Existing Traffic	212.0	6.35	10.3	6.35 : 21.05 : 27.4	9.15	3.2	14.15 : 9.15 : 3.2	
Diverted Traffic	7.0	24.5	3.85	28.35 : 28.35 : 4.75	7.6	12.8	4.75 : 7.6 : 12.8	
Local Traffic	219.0	6.15	10.75	6.15 : 21.3 : 27.45	9.0	14.1	9.0 : 3.35 : 14.1	

HIGHWAY PROJECT ANALYSIS

Traffic Income

Location of project Montana Description of project Ekalaka - Ridgeway County Carter
 Highway FAS #323 Highway System FA Secondary Length 35.0 miles Date of analysis March 1946

Traffic Type	Average Annual Traffic			Average Annual : Unit Net : Total Annual		
	Local Traffic		Diverted Traffic	: Road Use During: Revenues : Net Revenue		
	Vehicles	Ton	Vehicles	Ton	: Life of Project: Per Ton Mi:	
	Miles		Miles		Ton Miles	
: Passenger Cars - Montana	: 37,558	: 695,762	: 1,588	: 83,413	: 779,175	: \$0.002188 : \$1,705
: Passenger Cars - Foreign	: 1,606	: 29,751	: 273	: 14,331	: 144,082	: 0.001799 : 79
: Total passenger cars	: 39,164	: 725,513	: 1,871	: 97,744	: 823,257	: \$1,784
: Trucks, light	: 31,719	: 1,280,954	: 176	: 20,106	: 1,301,060	: 0.003248 : \$4,226
: Trucks, medium	: 3,212	: 272,923	: 43	: 10,498	: 283,421	: 0.002382 : 675
: Trucks, heavy	: 1,752	: 241,257	: 6	: 2,363	: 243,620	: 0.001619 : 394
: Trucks, semi-trailer	: 2,007	: 365,844	: 43	: 22,467	: 388,311	: 0.001543 : 599
: Trucks, full-trailer	: 949	: 268,279	: 17	: 13,229	: 281,508	: 0.001396 : 393
: Busses	: 1,132	: 125,822	: 44	: 13,701	: 139,523	: 0.001873 : 261
: Total trucks & busses	: 40,771	: 2,555,079	: 329	: 82,364	: 2,637,443	: \$6,548
: Total all vehicles	: 79,935	: 3,280,592	: 2,190	: 180,108	: 3,460,700	: \$8,332

Total Annual Income..... \$8,332

(Time Element Savings cont'd)

Private Passenger Cars (cont'd)		New	Old	New	Old
Distance (Miles).....		26.45	27.45		
Time (hours per trip).....		0.747	0.863		
Time savings per vehicle.....		0.116			
Value of savings (\$/vehicle-hour)		\$0.60			
Annual traffic volume.....		39,164			
Total.....	\$	2,726		\$934	
Trucks, Light					
Average speed (Miles per hour)...		32.4	28.8		
Distance (miles).....		26.45	27.45		
Time (hours per trip).....		0.816	0.953		
Time savings per vehicle.....		0.137			
Value of savings (\$/vehicle-hour)		\$0.86			
Annual traffic volume.....		31,719			
Total.....	\$	3,737		\$136	
Trucks, Medium					
Average speed (miles per hour)...		28.4	24.8		
Distance (miles).....		26.45	27.45		
Time (hours per trip).....		0.931	1.107		
Time savings per vehicle.....		0.176			
Value of savings (\$/vehicle-hour)		\$1.17			
Annual traffic volume.....		3,212			
Total.....	\$	661		\$51	
Trucks, Heavy					
Average speed (miles per hour)...		25.4	21.8		
Distance (miles).....		26.45	27.45		
Time (hours per trip).....		1.041	1.259		
Time savings per vehicle.....		0.218			
Value of savings (\$/vehicle-hour)		\$1.47			
Annual traffic volume.....		5,840			
Total.....	\$	1,871		\$179	
Total...each category.....	\$	8,995			\$1,300
TOTAL ANNUAL TIME ELEMENT SAVINGS.....				\$10,295	

e. Mileage Element Savings

As per tabulation set forth herebelow.

HIGHWAY PROJECT ANALYSIS

Mileage Element Savings

Location of project	MONTANA	County	CARTER
Description of Project	EKALAKA-RIDGEWAY		
Highway number	FAS No. 323	Highway system	FA SECONDARY
Length	35.0 Miles	Date of Analysis	APRIL 1946
	Local Traffic	Diverted Traffic	@ 45.8%

	Distance	New	Old	New	Old
Length (miles).....		26.45	27.45		
Distance saving (miles).....		1.0			

(Mileage Element Savings cont'd)				
Distance (cont'd)	Local Traffic		Diverted Traffic @ 45.8%	
	New	Old	New	Old
Average annual traffic (tons).....	265,635			
Annual traffic saving (ton-mi.).....	265,635			
Cost (\$/ton-mile).....	\$0.0178			
Total.....	\$ 4,728		\$ 3,488	
Surface				
Roadway surface type.....	0.183	0.260		
Saving coefficient.....	0.087			
Aver. annual traffic (ton-mi.).....	7,291,681			
Saving (\$/ton-mile).....	\$0.00155			
Total.....	\$11,302		\$22	
Alignment				
Curvature rating.....	4.7	2.2		
Points improvement.....	2.5			
Saving (point-ton-miles).....	16,041,698			
Saving (\$/point-ton-mile).....	\$0.0001			
Total.....	\$ 1,604		\$32	
Total.....each category.....	\$ 17,634		\$ 3,542	
TOTAL ANNUAL MILEAGE ELEMENT SAVINGS.....			\$21,176	

f. Traffic Benefits

See tabulation which follows:

HIGHWAY PROJECT ANALYSIS

Traffic Benefits

Location of project	MONTANA	County	CARTER
Description of project	EKALAKA-RIDGEWAY		
Highway number	FAS No. 323	Highway system	FA SECONDARY
Length	35.0 Miles	Date of Analysis	APRIL 1946

Mileage Element Factors

Item			Fuel Function	Non-fuel Function
Distance savings	\$8,216	38%	\$ 3,122	\$ 5,094
Roadway surface savings	11,324	43%	4,869	6,455
Alignment savings	1,636	50%	818	818
Total Mileage Savings	\$21,176		\$ 8,809	\$12,367

Time Element Factors

Type of Traffic	Annual Value of Time Savings
Passenger cars	\$ 3,660
Trucks, light	3,873
Trucks, medium	712
Trucks, heavy	2,050
Total Time Savings	\$ 10,295

(Traffic Benefits cont'd)

Recapitulation of Annual Benefits

Total Fuel Function Benefits	\$ 8,809
Non-fuel function (Mileage element factors	\$ 12,367
benefits (Time element factors	\$ 10,295
Total Non-fuel Function Benefits	\$ 22,662
TOTAL ANNUAL BENEFITS	\$ 31,471

g. Derivation of Quotients

See tabulations set forth herebelow.

HIGHWAY PROJECT ANALYSIS

Location of project	MONTANA	County	CARTER
Description of project	EKALAKA-RIDGEWAY		
Highway number	FAS No. 323	Highway System	FA SECONDARY
Length	35.0 Miles	Date of Analysis	APRIL 1946

$$I_{ar} = \$ 8,332 \quad K_1 = 1.00$$

$$C_a = \$ 34,239 \quad K_2 = 1,351/8,809 = 0.155$$

$$B_n = \$ 22,662 \quad K_3 = 0.05/0.20 = 0.25$$

$$B_f = \$ 8,809 \quad K_2 K_3 = 0.155 \times 0.25 = 0.04$$

$$K_1 C_a = \$ 34,239 \quad 1 - K_2 K_3 = 1.00 - 0.04 = 0.96$$

$$Q_s = I_{ar} / K_1 C_a = 8,332 / 34,239 = 0.245$$

$$Q_{Bn} = B_n / K_1 C_a = 22,662 / 34,239 = 0.66$$

$$Q_{Bf} = B_f / K_1 C_a = 8,809 / 34,239 = 0.255$$

$$Q'_s = Q_s - K_2 K_3 Q_{Bf} = 0.245 - 0.04 \times 0.255 = 0.245 - 0.01 = 0.235$$

$$Q_c = 0.707 (Q_s / Q_{Bn} / Q_{Bf} (1 - K_2 K_3)) = 0.707 (0.245 / 0.66 / 0.255 \times 0.96)$$

$$= 0.707 (0.245 / 0.66 / 0.245)$$

$$= 0.707 \times 1.15$$

$$= 0.81$$

3. EKALAKA-PINIELE ROAD: Oiled Surface, 18.5 miles; Gravel Surface, 19.5 miles; total distance, 38.0 miles.

a. Annual Cost Calculations

As set forth in Analysis A, sub-section 3,a.

b. Average Daily Traffic, 1960

(1) Local Traffic

Average daily traffic and travel-distance data are as shown on page 92.

(2) Diverted Traffic

This element of traffic, 6 vehicles per mile per day will be effective over 49.7% of the total length of the routing.

c. Annual Revenues

As per tabulation which is shown on page 93.

d. Time Element Savings

As per tabulation which follows:

HIGHWAY PROJECT ANALYSIS

Time Element Savings

Location of project	MONTANA	County	CARTER		
Description of project	EKALAKA-PINIELE ROAD				
Highway number	FAS No. 323	Highway System	FA SECONDARY		
Length	38.0 Miles	Date of Analysis	APRIL 1946		
		Local Traffic	Diverted Traffic @ 49.7%		
<u>Annual Traffic Volume</u>		New	Old	New	Old
Private Passenger cars (per year)		40,588			
Trucks, light (per year).....		32,886			
Trucks, medium (per year).....		3,321			
Trucks, heavy (per year).....		6,060			
Totals.....		82,855			
<u>Private Passenger Cars</u>					
Average speed (miles per hour)...		35.4	31.7		
Distance (miles).....		27.25	28.15		
Time (hours per trip).....		0.770	0.888		
Time savings per vehicle.....		0.118			
Value of savings (\$/vehicle-hour)		\$0.60			
Annual traffic volume.....		40,588			
Totals.....		\$ 2,874		\$ 1,014	
<u>Trucks, Light</u>					
Average speed (miles per hour)...		32.4	28.7		
Distance (miles).....		27.25	28.15		
Time (hours per trip).....		0.841	0.981		
Time savings per vehicle.....		0.140			
Value of savings (\$/vehicle-hour)		\$0.86			
Annual traffic volume.....		32,886			
Totals.....		\$ 3,959		\$148	
<u>Trucks, Medium</u>					
Average speed (miles per hour)...		28.4	24.7		
Distance (miles).....		27.25	28.15		
Time (hours per trip).....		0.959	1.140		
Time savings per vehicle.....		0.181			
Value of savings (\$/vehicle-hour)		\$1.17			
Annual traffic volume.....		3,321			
Total.....		\$ 703		\$55	

LOCAL TRAFFIC WITH TRAVEL-DISTANCE DATA AS OF
COMPLETION OF THE EKALAKA-PINIELE ROAD SECTION
OF THE EKALAKA-RIDGEMAY-ALBION-ALZADA ROUTING

TRAFFIC CLASSIFICATION	ADT	EXISTING FACILITIES (Miles)			NEW FACILITIES (Miles)		
		PTW	APPROACH	TOTAL TRAVEL-DISTANCE	NEW	APPROACH	TOTAL TRAVEL-DISTANCE
		GRAVEL:UNIMP:	UNIMP: OIL :GRAVEL:	UNIMP:TOTAL: OIL :GRAVEL:	UNIMP : OIL :GRAVEL:	UNIMP : OIL :GRAVEL:	UNIMP:TOTAL:
Existing Traffic	220	6.1 :10.4 :	11.65:	6.1 :22.05:28.15:	4.0 : 14.55 :8.75 :	4.0 : 14.55 :8.75 :	14.55:27.3 :
Diverted Traffic	7	24.1 :	3.8 :	27.9 :27.9 :	4.7 : 8.05: 12.0 :	4.7 : 8.05 :12.0 :	24.75:
Local Traffic	227	5.9 :10.8 :	11.45:	5.9 :22.25:28.15:	4.15: 14.5 :8.6 :	4.15 :14.5 :8.6 :	27.25:

HIGHWAY PROJECT ANALYSIS

Traffic Income

Location of project Montana Highway FAS No. 323 Description of project Ekalaka - Pinele Road Length 38.0 Miles Date of analysis April 1946

County Carter

Traffic Type	Average Annual Traffic						Average Annual			Unit Net	Total Annual
	Local Traffic			Diverted Traffic			Road Use During			Revenues	Net Revenue
	Vehicles		Ton	Vehicles		Ton	Life of Project		Per Ton Mi.		
	Miles		Miles		Miles		Ton Mi.				
Passenger Cars - Montana	38,946		744,842	1,588	90,561		835,403	\$0.002188		\$1,828	
Passenger Cars - Foreign	1,642		31,403	273	15,560		46,963		0.001799	84	
Total passenger cars	40,588		776,245	1,861	106,121		882,366			\$1,912	
Trucks, light	32,886		1,371,097	176	21,828		1,392,925		0.003248	\$4,524	
Trucks, medium	3,321		291,312	43	11,399		302,711		0.002382	721	
Trucks, heavy	1,825		259,450	6	2,565		262,015		0.001619	424	
Trucks, semi-trailer	2,081		391,629	43	24,393		416,022		0.001543	642	
Trucks, full-trailer	986		287,768	17	14,362		302,130		0.001396	422	
Busses, other	1,168		134,028	44	14,876		148,904		0.001873	279	
Total trucks & busses	42,267		2,735,284	329	89,423		2,824,707			\$7,012	
Total all vehicles	82,855		3,511,529	2,190	195,544		3,707,073			\$8,924	

Total Annual Income..... \$8,924

(Time Element Savings cont'd)

Trucks, Heavy	Local Traffic		Diverted Traffic	
	New	Old	New@ 49.7%	Old
Average speed (miles per hour)...	25.4	21.7		
Distance (miles).....	27.25	28.15		
Time (hours per trip).....	1.072	1.297		
Time savings per vehicle.....	0.225			
Value of savings (\$/vehicle-hour)	\$1.47			
Annual traffic volume.....	6,060			
Total.....	\$ 2,004		\$ 194	
Total....each category.....	\$ 9,540		\$ 1,411	
TOTAL ANNUAL TIME ELEMENT SAVINGS.....			\$ 10,951	

- e. Mileage Element Savings
As per tabulation which follows:

HIGHWAY PROJECT ANALYSIS

Location of project		MONTANA		County		CARTER		Mileage Element Savings			
Description of Project		EKALAKA-PINIELE ROAD									
Highway number		FAS No. 323		Highway System		FA SECONDARY					
Length		38.0 Miles		Date of Analysis		APRIL 1946					
				Local Traffic		Diverted Traffic					
						@ 49.7%					
Distance				New		Old		New		Old	
Length(miles).....				27.25		28.15					
Distance saving (miles).....				0.90							
Average annual traffic (tons).....				275,414							
Annual traffic saving (ton-mi.).....				247,873							
Cost (\$/ton-mile).....				\$0.0178							
Total.....				\$ 4,412				\$ 3,785			
Surface											
Roadway surface type.....				0.187		0.261					
Saving coefficient.....				0.074							
Aver. annual traffic (ton-mi.).....				7,752,904							
Saving (\$/ton-mile).....				\$0.0013							
Total.....				\$ 10,079				\$ 23			
Alignment											
Curvature rating.....				4.7		2.1					
Points improvement.....				2.6							
Saving (point-ton-miles).....				20,157,550							
Saving (\$/point-ton-mile).....				\$0.0001							
Total.....				\$ 2,016				\$ 35			
Total....each category.....				\$ 16,507				\$ 3,843			
TOTAL ANNUAL MILEAGE ELEMENT SAVINGS.....								\$ 20,350			

- f. Traffic Benefits
As per tabulation which follows:

HIGHWAY PROJECT ANALYSIS

Traffic Benefits

Location of project MONTANA County CARTER
 Description of project EKALAKA-PINIELE ROAD
 Highway number FAS No. 323 Highway System FA SECONDARY
 Length 38.0 Miles Date of Analysis APRIL 1946

Mileage Element Factors

Item			Fuel Function	Non-fuel Function
Distance savings	\$8,197	38%	\$ 3,115	\$ 5,082
Roadway surface savings	10,102	43%	4,344	5,758
Alignment savings	2,051	50%	1,026	1,025
Total Mileage Savings	\$20,350		\$ 8,485	\$ 11,865

Time Element Factors

Type of Traffic	Annual Value of Time Savings
Passenger cars	\$ 3,888
Trucks, light	4,107
Trucks, medium	758
Trucks, heavy	2,198
Total Time Savings	\$ 10,951

Recapitulation of Annual Benefits

Total Fuel Function Benefits	\$ 8,485
Non-fuel Function (Mileage element factors	\$ 11,865
benefits (Time element factors	\$ 10,951
Total Non-fuel Function Benefits	\$22,816
TOTAL ANNUAL BENEFITS	\$31,301

g. Derivation of Quotients
 As per tabulation which follows:

HIGHWAY PROJECT ANALYSIS

Location of project MONTANA County CARTER
 Description of project EKALAKA-PINIELE ROAD
 Highway number FAS No. 323 Highway system FA SECONDARY
 Length 38.0 Miles Date of Analysis APRIL 1946

Iar = \$ 8,924 $K_1 = 1.00$
 Ca = \$ 37,437 $K_2 = 1,466/8,485 = 0.17$

(Derivation of Quotients cont'd)

$$\begin{aligned}
B_n &= \$ 22,816 & K_3 &= 0.05/0.20 = 0.25 \\
B_f &= \$ 8,485 & K_2 K_3 &= 0.17 \times 0.25 = 0.04 \\
K_1 C_a &= \$ 37,437 & 1-K_2 K_3 &= 1.00 - 0.04 = 0.96 \\
Q_s &= I_{ar}/K_1 C_a = 8,924/37,437 = 0.24 \\
Q_{Bn} &= B_n/K_1 C_a = 22,816/37,437 = 0.61 \\
Q_{Bf} &= B_f/K_1 C_a = 8,485/37,437 = 0.225 \\
Q'_s &= Q_s - K_2 K_3 Q_{Bf} = 0.24 - 0.04 \times 0.225 = 0.24 - 0.01 = 0.23 \\
Q_c &= 0.707 (Q_s/Q_{Bn} \cdot Q_{Bf}(1-K_2 K_3)) = 0.707 (0.24 / 0.61 \cdot 0.225 \times 0.96) \\
&= 0.707 (0.24 / 0.61 \cdot 0.215) \\
&= 0.707 \times 1.065 \\
&= 0.75
\end{aligned}$$

4. EKALAKA-ALBION: Oiled Surface, 18.5 miles; Gravel Surface, 43.5 miles; total distance, 62.0 miles.

a. Annual Cost Calculations

Construction costs are summarized as follows:

Re-grading, 9.5 miles @ \$1,500 per mile.....	\$14,250
Grading, 52.5 miles @ \$4,000 per mile.....	\$210,000
Gravel Base and Surface, 62.0 miles @ \$3,500 per mile.....	\$217,000
Major Drainage Structures, bridges	
4 Steel, 450 feet @ \$150 per lineal foot.....	\$67,500
14 Timber, 840 feet @ \$100 per lineal foot.....	\$84,000
Minor Drainage Structures, 52.5 miles @ \$800 per mile.....	\$42,000
Oiled Surface, 18.5 miles @ \$2,000 per mile.....	\$37,000
Rights of Way	
9.0 miles @ \$500 per mile.....	\$4,500
43.5 miles @ \$400 per mile.....	\$17,400
Engineering and Administration	
Grading, gravel, and oil 9.0 miles @ \$1,000 per mile.....	\$9,000
Re-gravel and oil 9.5 miles @ \$600 per mile.....	\$5,700
Grade and gravel 43.5 miles @ \$800 per mile.....	\$34,800
Bridges, 5% of \$151,500.....	\$7,575

Sub-total..... \$750,725

✓ 10% for contingencies..... \$75,073

Total construction costs, 62.0 miles..... \$825,798

These data are condensed in the tabulation which follows and extended to cover interest charges and maintenance costs to arrive at an annual capital cost.

HIGHWAY PROJECT ANALYSIS

Annual Cost Calculations

Location of project	MONTANA	County	CARTER
Description of project	EKALAKA-ALBION		
Highway number	FAS No. 323	Highway system	FA SECONDARY
Length	62.0 Miles	Date of Analysis	MARCH 1946

	CAPITAL COSTS			Annual
Item	Net Cost	Interest Rate	Amort. Period	Capital Cost
Rights of way, easements, etc.	\$ 21,900	2 1/2%	20 yrs.	\$ 1,404
Clearing, grading, etc.	224,250	"	"	14,374
Pavements and surfacing:				
Type Gravel Base & Surface	217,000	"	"	13,910
Type Oil Surface	37,000	"	"	2,372
Structures:				
Type Major, 4 Steel	67,500	"	"	4,327
Type Major, 14 Timber	84,000	"	"	5,384
Type Minor	42,000	"	"	2,692
Engineering and Administration..	57,075	"	"	3,659
✓ 10% for contingencies.....	75,073	"	"	4,812
1. Total annual capital cost.....				\$ 52,934

2. Total annual maintenance cost 62.0 miles @ \$100 \$ 6,200

TOTAL ANNUAL COSTS (1 ✓ 2) \$ 59,134

b. Average Daily Traffic, 1960

(1) Local Traffic

Average daily traffic and travel-distance data are as shown on page 98.

(2) Diverted Traffic

Effective over 81% of the total length of the routing.

c. Annual Revenues

As per tabulation which is shown on page 99.

d. Time Element Savings

As per tabulation which follows:

LOCAL TRAFFIC AND TRAVEL-DISTANCE DATA AS OF
COMPLETION OF THE EKALAKA-ALBION SECTION OF
THE EKALAKA-RIDGEWAY-ALBION-ALZADA ROUTING

TRAFFIC CLASSIFICATION	EXISTING FACILITIES (Miles)					NEW FACILITIES (Miles)				
	ADT	GRAVEL:UNIMP	OIL	UNIMP	TOTAL TRAVEL-DISTANCE	NEW	APPROACH	GRAVEL	UNIMP	APPROACH: TOTAL TRAVEL-DISTANCE
Existing Traffic	246	5.45	11.2	11.95	5.45 : 23.15 : 28.6	7.7	7.3	7.3	12.75	7.7 : 7.3 : 12.75 : 27.75
Diverted Traffic	37		21.3	6.4	5.6 : 26.9 : 33.3	0.9	14.1	14.1	11.65	0.9 : 14.1 : 11.65 : 26.65
Local Traffic	283	4.75	12.5	0.85	4.75 : 23.6 : 29.2	6.8	8.2	8.2	12.6	6.8 : 8.2 : 12.6 : 27.6

Location of project Montana Description of project Ekalaka - Albion County Carter
 Highway FAS No. 323 Highway System FA Secondary Length 62.0 miles Date of analysis April 1946

Traffic Type	Average Annual Traffic				:Average Annual : Unit Net : Total Annual	
	Local Traffic		Diverted Traffic		:Road Use During: Revenues : Net Revenue	
	Vehicles : Ton	Vehicles : Miles	Ton	Miles	:Life of Project:Per Ton Mi:	
Passenger Cars - Montana	48,545	: 1,092,270:	1,588	: 147,725	: 1,239,995	: \$0.002188 : \$2,713
Passenger Cars - Foreign	2,080	: 46,800:	273	: 25,344	: 72,144	: 0.001799 : 130
Total passenger cars	50,625	:1,139,070:	1,861	: 173,069	: 1,312,139	: \$2,843
Trucks, light	41,026	:2,012,325:	176	: 35,568	: 2,047,893	: 0.003248 : \$6,652
Trucks, medium	4,124	: 425,595:	43	: 18,589	: 444,184	: 0.002382 : 1,058
Trucks, heavy	2,263	: 378,480:	6	: 4,151	: 382,631	: 0.001619 : 619
Trucks, semi-trailer	2,592	: 573,870:	43	: 39,782	: 613,652	: 0.001543 : 947
Trucks, full-trailer	1,241	: 426,090:	17	: 23,423	: 449,513	: 0.001396 : 628
Busses, other	1,424	: 192,240:	44	: 24,290	: 216,530	: 0.001873 : 406
Total trucks & busses	52,670	:4,008,600:	329	: 145,803	: 4,154,403	: \$10,310
Total all vehicles	103,295	:5,147,670:	2,190	: 318,872	: 5,466,542	: \$13,153
Total annual income.....						\$13,153

HIGHWAY PROJECT ANALYSIS

		Time Element Savings	
Location of project	MONTANA	County	CARTER
Description of project	EKALAKA-ALBION		
Highway number	FAS No. 323	Highway system	FA SECONDARY
Length	62.0 Miles	Date of Analysis	APRIL 1946
		Local Traffic	Diverted Traffic @ 81%
Annual Traffic Volume		New	Old
Private Passenger cars (per year)		50,625	
Trucks, light (per year).....		41,026	
Trucks, medium (per year).....		4,124	
Trucks, heavy (per year).....		7,520	
Totals.....		103,295	
Private Passenger Cars			
Average speed (miles per hour)...		35.6	31.7
Distance (Miles).....		27.6	29.2
Time (hours per trip).....		0.775	0.921
Time savings per vehicle.....		0.146	
Value of savings (\$/vehicle-hour)		\$0.60	
Annual traffic volume.....		50,625	
Totals.....		\$ 4,435	\$ 1,652
Trucks, Light			
Average speed (miles per hour)...		32.6	28.7
Distance (miles).....		27.6	29.2
Time (hours per trip).....		0.847	1.017
Time savings per vehicle.....		0.170	
Value of savings (\$/vehicle-hour)		\$0.86	
Annual traffic volume.....		41,026	
Totals.....		\$ 5,998	\$ 241
Trucks, Medium			
Average speed (miles per hour)...		28.6	24.7
Distance (miles).....		27.6	29.2
Time (hours per trip).....		0.965	1.182
Time savings per vehicle.....		0.217	
Value of savings (\$/vehicle-hour)		\$1.17	
Annual traffic volume.....		4,124	
Totals.....		\$ 1,047	\$ 90
Trucks, Heavy			
Average speed (miles per hour)...		25.6	21.7
Distance (miles).....		27.6	29.2
Time (hours per trip).....		1.078	1.346
Time savings per vehicle.....		0.288	
Value of savings (\$/vehicle-hour)		\$1.47	
Annual traffic volume.....		7,520	
Totals.....		\$ 2,963	\$ 316
Total.....each category.....		\$14,443	\$ 2,299
TOTAL ANNUAL TIME ELEMENT SAVINGS.....			\$ 16,742

Note the effect of the increased local diversionary traffic to render a relatively high value of Time Element Savings.

e. Mileage Element Savings
As per tabulation which follows:

HIGHWAY PROJECT ANALYSIS

Mileage Element Savings

Location of project		MONTANA		County		CARTER			
Description of project		EKALAKA-ALBION							
Highway number		FAS No. 323		Highway system		FA SECONDARY			
Length		62.0 Miles		Date of Analysis		APRIL 1946			
				Local Traffic		Diverted Traffic			
						@ 81%			
Distance		New		Old		New		Old	
Length (miles).....		27.6		29.2					
Distance saving(miles).....		1.6							
Average annual traffic (tons).....		343,178							
Annual traffic saving (ton-mi.).....		549,085							
Cost (\$/ton-mile).....		\$0.0178							
Total.....		\$ 9,774				\$ 6,168			
Surface									
Roadway surface type.....		0.191		0.258					
Saving coefficient.....		0.067							
Aver. annual traffic (ton-mi.).....		10,020,798							
Saving (\$/ton-mile).....		\$0.0012							
Total.....		\$ 12,025				\$38			
Alignment									
Curvature rating.....		5.4		1.9					
Points improvement.....		3.5							
Saving (point-ton-miles).....		35,072,793							
Saving (\$/point-ton-mile).....		\$0.0001							
Total.....		\$ 3,507				\$57			
Total.....Each category.....		\$ 25,306				\$ 6,263			
TOTAL ANNUAL MILEAGE ELEMENT SAVINGS.....						\$ 31,569			

f. Traffic Benefits
As per tabulation which follows:

HIGHWAY PROJECT ANALYSIS

Traffic Benefits

Location of project	MONTANA	County	CARTER
Description of project	EKALAKA-ALBION		
Highway number	FAS No. 323	Highway system	FA SECONDARY
Length	62.0 Miles	Date of Analysis	APRIL 1946

Mileage Element Factors

Item			Fuel Function	Non-fuel Function
Distance savings	\$15,942	38%	\$ 6,058	\$ 9,884
Roadway surface savings	12,063	45%	5,428	6,635
Alignment savings	3,564	50%	1,782	1,782
Total Mileage Savings	\$31,569		\$ 13,268	\$ 18,301

(Traffic Benefits cont'd)

<u>Time Element Factors</u>	
Type of Traffic	Annual Value of Time Savings
Passenger cars	\$ 6,087
Trucks, light	6,239
Trucks, medium	1,137
Trucks, heavy	3,279
Total Time Savings	\$ 16,742

Recapitulation of Annual Benefits

Total Fuel Function Benefits	\$ 13,268
Non-fuel function (Mileage element factors benefits (Time element factors	\$ 18,301 \$ 16,742
Total Non-fuel Function Benefits	\$ 35,043
TOTAL ANNUAL BENEFITS	\$ 48,311

g. Derivation of Quotients

As per tabulation set forth herebelow:

HIGHWAY PROJECT ANALYSIS

Location of project	MONTANA	County	CARTER
Description of project	EKALAKA-ALBION		
Highway number	FAS No. 323	Highway system	FA SECONDARY
Length	62.0 Miles	Date of Analysis	APRIL 1946

$I_{ar} = \$$	13,153	K_1	$= 1.00$
$C_a = \$$	59,134	K_2	$= 2,389/13,268 = 0.18$
$B_n = \$$	35,043	K_3	$= 0.05/0.20 = 0.25$
$B_f = \$$	13,268	$K_2 K_3$	$= 0.18 \times 0.25 = 0.045$
$K_1 C_a = \$$	59,134	$1 - K_2 K_3$	$= 1.00 - 0.045 = 0.955$
$Q_s = I_{ar}/K_1 C_a =$	$13,153/59,134 = 0.22$		
$Q_{Bn} = B_n/K_1 C_a =$	$35,043/59,134 = 0.595$		
$Q_{Bf} = B_f/K_1 C_a =$	$13,268/59,134 = 0.225$		
$Q's = Q_s - K_2 K_3 Q_{Bf} =$	$0.22 - 0.045 \times 0.225 = 0.22 - 0.01 = 0.21$		

(Derivation of Quotients cont'd)

$$\begin{aligned}
 Q_0 &= 0.707 (Q_s \cdot Q_{BN} \cdot Q_{BF} (1 - K_2 K_3)) = 0.707 (0.22 \cdot 0.595 \cdot 0.225 \times 0.955) \\
 &= 0.707 (0.22 \cdot 0.595 \cdot 0.215) \\
 &= 0.707 \times 1.03 \\
 &= 0.73
 \end{aligned}$$

The analysis displays the fact that a high economic rating is maintained although traffic volume is decreased somewhat along that interval extending from the Piniele road turn-off to Albion, and the routing meets with additional costs for steel bridge construction.

5. EKALAKA-ALZADA: Oiled Surface, 33.0 miles; Gravel Surface, 43.5 miles; total distance, 76.5 miles.

a. Annual Cost Calculation

Details of construction costs are as follows:

Re-grading, 9.5 miles @ \$1,500 per mile.....	\$14,250
Grading, 67.0 miles @ \$4,000 per mile.....	\$268,000
Gravel Base and Surface, 76.5 miles @ \$3,500 per mile.....	\$267,750
Major Drainage Structures, bridges	
4 Steel, 450 feet @ \$150 per lineal foot.....	\$67,500
17 Timber, 1,020 feet @ \$100 per lineal foot.....	\$102,000
Minor Drainage Structures, 67.0 miles @ \$800 per mile.....	\$53,600
Oiled Surface 18.5 miles @ \$2,000 per mile.....	\$37,000
Rights-of-Way	
23.5 miles @ \$500 per mile.....	\$11,750
43.5 miles @ \$400 per mile.....	\$17,400
Engineering and Administration	
Grading, gravel and oil 23.5 miles @ \$1,000 per mile....	\$23,500
Re-gravel and oil 9.5 miles @ \$600 per mile.....	\$5,700
Grade and gravel 43.5 miles @ \$800 per mile.....	\$34,800
Bridges, 5% of \$169,500.....	\$8,475
Sub-total.....	\$940,725
+ 10% for contingencies.....	\$94,073
Total construction costs, 76.5 miles.....	\$1,034,798

These data are summarized in the tabulation which follows to arrive at an annual construction capital cost which comprehends interest charges at the rate of 2½% to be amortized in 20 years. These costs in

combination with estimated maintenance charges render a total annual capital cost.

ANNUAL COST CALCULATIONS

Location of project	<u>MONTANA</u>	County	<u>CARTER</u>
Description of project	<u>EKALAKA-ALZADA</u>		
Highway number	<u>FAS No. 323</u>	Highway system	<u>FA SECONDARY</u>
Length	<u>76.5 Miles</u>	Date of Analysis	<u>April 1946</u>

CAPITAL COSTS

Item	Net Cost	Interest Rate	Amort. Period	Annual Capital Cost
Rights of way, easements, etc.	\$ 29,150	2 $\frac{1}{2}$ %	20 years	\$ 1,869
Clearing, grading, etc.	282,250	"	"	18,092
Pavements and surfacing:				
Type Gravel Base & Surface	267,750	"	"	17,163
Type Oil Surface	66,000	"	"	4,231
Structures:				
Type Major, 4 Steel	67,500	"	"	4,327
Type Major, 17 Timber	102,000	"	"	6,538
Type Minor	53,600	"	"	3,436
Engineering & Administration....	72,475	"	"	4,646
+ 10% for contingencies.....	94,073	"	"	6,030
1. Total annual capital cost.....				\$ 66,332
2. Total annual maintenance cost	76.5 mi. @ \$100.00			\$ 7,650
TOTAL ANNUAL COSTS (1 + 2)				\$ 73,982

b. Average Daily Traffic, 1960

(1) Local Traffic

Average traffic and travel-distance data are set forth as shown on page 105.

(2) Diverted Traffic

Six vehicles per mile per day effective over the total length of the routing.

c. Annual Revenues

As per tabulation set forth on page 106.

d. Time Element Savings

As per tabulation set forth herebelow.

HIGHWAY PROJECT ANALYSIS

Location of project	<u>MONTANA</u>	Time Element Savings	
Description of project	<u>EKALAKA-ALZADA</u>	County	<u>CARTER</u>
Highway number	<u>FAS No. 323</u>	Highway system	<u>FA SECONDARY</u>
Length	<u>76.5 Miles</u>	Date of Analysis	<u>APRIL 1946</u>

LOCAL TRAFFIC AND TRAVEL-DISTANCE DATA AS OF
COMPLETION OF THE EKALAKA-ALZADA ROUTING VIA
SYKES BRIDGE-RIDGEWAY AND ALBION

TRAFFIC CLASSIFICATION	EXISTING FACILITIES (Miles)			NEW FACILITIES (Miles)		
	PTW	APPROACH	TOTAL TRAVEL-DISTANCE	NEW	APPROACH	TOTAL TRAVEL-DISTANCE
	ADT	GRAVEL:UNIMP:	OIL :UNIMP:	OIL :GRAVEL:	UNIMP :	OIL :GRAVEL:UNIMP:TOTAL:
Existing Traffic	355	3.8	10.1	12.0	3.8	22.1 :25.9 :8.3 :5.0 :12.0 :25.3
Diverted Traffic	56		14.1	4.25	3.35:4.25	17.45:21.7 :3.95:9.35 :4.35:17.65:
Local Traffic	411	3.3	10.65:0.55	10.8 :0.55	3.3	21.45:25.3 :7.7 :5.6 :10.95:24.25:

HIGHWAY PROJECT ANALYSIS

Traffic Income

Location of project Montana Highway FAS #323 Description of project Ekalaka - Alzada Length 76.5 mi. Date of analysis April 1946

TRAFFIC TYPE		Average Annual Traffic		Diverted Traffic		Average Annual		Unit Net		Total Annual	
		Local Traffic				Road Use During		Revenues		Net Revenue	
		Vehicles	Ton	Vehicles	Ton	Life of Project	Per ton	Mi.			
		Miles	Miles	Miles	Miles						
Passenger Cars - Montana		70,518	1,406,834	1,588	182,376	1,589,210	\$0.002188		\$	3,477	
Passenger Cars - Foreign		2,993	59,717	273	31,289	91,006	0.001799			164	
Total passenger cars		73,511	1,466,551	1,861	213,665	1,680,216			\$	3,641	
Trucks, light		59,568	2,590,667	176	43,911	2,634,578	0.003248		\$	8,557	
Trucks, medium		5,986	547,747	43	22,950	570,697	0.002382			1,359	
Trucks, heavy		3,285	487,152	6	5,125	492,277	0.001619			797	
Trucks, semi-trailer		3,760	738,123	43	49,113	787,236	0.001543			1,215	
Trucks, full-trailer		1,789	544,635	17	28,917	573,552	0.001396			801	
Busses		2,117	253,405	44	29,988	283,393	0.001873			531	
Total trucks & busses		76,505	5,161,729	329	180,004	5,341,733			\$	13,260	
Total all vehicles		150,016	6,628,280	2,190	393,669	7,021,949			\$	16,901	
Total Annual Income.....										\$	16,901

		(Time Element Savings cont'd)			
		Local Traffic		Diverted Traffic	
		@ 100%			
Annual Traffic Volume		New	Old	New	Old
Private Passenger cars (per year)		73,511			
Trucks, light (per year).....		59,568			
Trucks, medium (per year).....		5,986			
Trucks, heavy (per year).....		10,951			
Totals.....		150,016			
Private Passenger Cars					
Average speed (miles per hour)...		360	31.3		
Distance (Miles).....		24.25	25.3		
Time (hours per trip).....		0.674	0.808		
Time savings per vehicle.....		0.134			
Value of savings (\$/vehicle-hour)		\$0.60			
Annual traffic volume.....		73,511			
Total.....		\$ 5,910		\$ 2,040	
Trucks, Light					
Average speed (miles per hour)...		33.0	28.3		
Distance (miles).....		24.25	25.3		
Time (hours per trip).....		0.735	0.894		
Time savings per vehicle.....		0.159			
Value of savings (\$/vehicle-hour)		\$0.86			
Annual traffic volume.....		59,568			
Total.....		\$ 8,145		\$ 298	
Trucks, Medium					
Average speed (miles per hour)...		29.0	24.3		
Distance (miles).....		24.25	25.3		
Time (hours per trip).....		0.836	1.041		
Time savings per vehicle.....		0.205			
Value of savings (\$/vehicle-hour)		\$1.17			
Annual traffic volume.....		5,986			
Total.....		\$ 1,436		\$ 111	
Trucks, Heavy					
Average speed (miles per hour)...		26.0	21.3		
Distance (miles).....		24.25	25.3		
Time (hours per trip).....		0.933	1.188		
Time savings per vehicle.....		0.255			
Value of savings (\$/vehicle-hour)		\$1.47			
Annual traffic volume.....		10,951			
Total.....		\$ 4,105		\$ 390	
Total.....each category.....		\$ 19,596		\$ 2,839	
TOTAL ANNUAL TIME ELEMENT SAVINGS.....				\$ 22,435	

e. Mileage Element Savings

As per tabulation set forth herebelow.

HIGHWAY PROJECT ANALYSIS

		Mileage Element Savings	
Location of project	MONTANA	County	CARTER
Description of Project	EKALAKA-ALZADA		
Highway number	FAS No. 323	Highway system	FA SECONDARY
Length	76.5 Miles	Date of Analysis	APRIL 1946

(Mileage Element Savings cont'd)				
	Local Traffic		Diverted Traffic @ 100%	
Distance	New	Old	New	Old
Length (miles).....	24.25	25.3		
Distance saving (miles).....	1.03			
Average annual traffic (tons).....	498,367			
Annual traffic saving (ton-mi.)....	523,285			
Cost (\$/ton-mile).....	\$0.0178			
Total.....	\$ 9,314		\$ 7,615	
Surface				
Roadway surface type.....	0.180	0.263		
Saving coefficient.....	0.083			
Aver. annual traffic (ton-mi.).....	12,608,685			
Saving (\$/ton-mile).....	\$0.0015			
Total.....	\$ 18,913		\$47	
Alignment				
Curvature rating.....	5.5	1.5		
Points improvement.....	4.0			
Saving (point-ton-miles).....	50,434,740			
Saving (\$/point-ton-mile).....	\$0.0001			
Total.....	\$ 5,043		\$70	
Total....each category.....	\$ 33,270		\$ 7,732	
TOTAL ANNUAL MILEAGE ELEMENT SAVINGS.....			\$ 41,002	

f. Traffic Benefits

See tabulation which follows:

HIGHWAY PROJECT ANALYSIS

		Traffic Benefits	
Location of project	MONTANA	County	CARTER
Description of project	EKALAKA-ALZADA		
Highway number	FAS No. 323	Highway system	FA SECONDARY
Length	76.5 Miles	Date of Analysis	APRIL 1946

Mileage Element Factors

Item			Fuel Function	Non-fuel Function
Distance savings	\$16,929	38%	\$ 6,433	\$ 10,496
Roadway surface savings	18,960	44.5%	8,437	10,523
Alignment savings	5,113	50%	2,557	2,556
Total Mileage Savings	\$41,002		\$ 17,427	\$ 23,575

Time Element Factors

Type of Traffic	Annual Value of Time Savings
Passenger cars	\$ 7,950

	(Traffic Benefits cont'd)
Trucks, light	\$ 8,443
Trucks, medium	1,547
Trucks, heavy	4,495
Total Time Savings	\$22,435

Recapitulation of Annual Benefits

Total Fuel Function Benefits	\$ 17,427
Non-fuel function (Mileage element factors	\$ 23,575
benefits (Time element factors	\$ 22,435
Total Non-fuel Function Benefits	\$ 46,010
TOTAL ANNUAL BENEFITS	\$ 63,437

g. Derivation of Quotients
See tabulation which follows:

HIGHWAY PROJECT ANALYSIS

Location of project	MONTANA	County	CARTER
Description of project	EKALAKA-ALZADA		
Highway number	FAS No. 323	Highway system	FA SECONDARY
Length	76.5 Miles	Date of Analysis	APRIL 1946

$$\begin{aligned}
 I_{ar} &= \$ 16,901 & K_1 &= 1.00 \\
 C_a &= \$ 73,982 & K_2 &= 2,950/17,427 = 0.17 \\
 B_n &= \$ 46,010 & K_3 &= 0.05/0.20 = 0.25 \\
 B_f &= \$ 17,427 & K_2 K_3 &= 0.17 \times 0.25 = 0.0425 \\
 K_1 C_a &= \$ 73,982 & 1 - K_2 K_3 &= 1.00 - 0.0425 = 0.9575 \\
 Q_s &= I_{ar} / K_1 C_a = 16,901 / 73,982 = 0.23 \\
 Q_{Bn} &= B_n / K_1 C_a = 46,010 / 73,982 = 0.62 \\
 Q_{Bf} &= B_f / K_1 C_a = 17,427 / 73,982 = 0.235 \\
 Q'_s &= Q_s - K_2 K_3 Q_{Bf} = 0.23 - 0.0425 \times 0.235 = 0.23 - 0.01 = 0.22 \\
 Q_c &= 0.707 (Q_s / Q_{Bn} / Q_{Bf} (1 - K_2 K_3)) = 0.707 (0.23 / 0.62 / 0.235 \times 0.9575) \\
 &= 0.707 (0.23 / 0.62 / 0.225) \\
 &= 0.707 \times 1.075 \\
 &= 0.76
 \end{aligned}$$

Here, as shown in the SUMMARY OF FINDINGS, we find the highest of all solvency ratings for any routing extending from Ekalaka to Alzada.

D. EKALAKA-ALZADA; Primary 7.0 miles and Secondary 76.0 miles, via Chalk Buttes, Ridgeway, Piniele Road turn-off near Hay Creek and a point on US 212 (Federal Aid Route No. 23) about 7 miles northwest of Alzada. It is proposed to explore the possibilities of routing the Ekalaka-Alzada road through Chalk Buttes, this town being an important trading center in Carter County. If this routing were chosen as the proper connection between Ekalaka and Chalk Buttes it would avoid several major stream crossings to allow a significant decrease in bridge construction costs, which, from the standpoint of highway economics is a desirable feature. But since we are considering the Carter County problem in its whole aspect we know that we will not be solving the problem solely by avoiding costly construction. We know that there are certain number of bridges which have to be replaced by either the state or county agencies and we know that the state is better prepared to do bridge construction work than the county. This phase of the problem has been pointed out in some considerable detail because some of the solvency quotients developed in subsequent sections of this analysis and Analysis E are surprisingly high when considered in reference to present and probable future traffic volumes. It is to be remembered that the solvency quotients are high, comparatively speaking, because of the virtual absence of bridge construction costs on the northerly half of the routing.

1. EKALAKA-BROADUS ROAD: Oiled Surface, 19.5 miles; Gravel Surface, 4.0 miles; total distance, 23.5 miles.

a. Annual Cost Calculations

Construction costs are summarized as follows:

Grading, 23.5 miles @ \$4,000 per mile.....	\$94,000
Gravel Base and Surface, 23.5 miles @ \$3,500 per mile.....	\$82,250
Minor Drainage Structures, 23.5 miles @ \$800 per mile.....	\$18,800
Oiled Surface, 19.5 miles @ \$2,000 per mile.....	\$39,000
Rights-of-Way	
19.5 miles @ \$500 per mile.....	\$9,750
4.0 miles @ \$400 per mile.....	\$1,600
Engineering and Administration	
Grading, graveling, and oiling, 19.5 miles @ \$1,000	
per mile....	\$19,500
Grade and Gravel 4.0 miles @ \$800 per mile.....	\$3,200
Sub-total.....	\$268,100
/ 10% for contingencies.....	\$26,810
Total construction costs, 23.5 miles.....	\$294,910

These data are consolidated in the tabulation which follows to show the application of interest charges and then extended to arrive at an annual capital cost value for construction. To this value there is added the estimated annual maintenance costs to arrive at the total annual cost of the routing.

ANNUAL COST CALCULATIONS			
Location of project	MONTANA	County	CARTER
Description of project	EKALAKA-BROADUS ROAD		
Highway number	FAS No. 323	Highway system	FA SECONDARY
Length	23.5 Miles	Date of analysis	APRIL 1946

CAPITAL COSTS				Annual
Item	Net Cost	Interest Rate	Amort. Period	Capital Cost
Rights of way, easements, etc.	\$ 11,350	2 1/2%	20 yrs.	\$ 728
Clearing, grading, etc.	94,000	"	"	6,025
Pavements and surfacing:				
Type Gravel Base & Surface	82,250	"	"	5,272
Type Oil Surface	39,000	"	"	2,500
Structures:				
Type Minor	18,800	"	"	1,205
Engineering & Administration.....	22,700	"	"	1,455
✓ 10% for Contingencies.....	26,810	"	"	1,719
1. Total annual capital cost.....				\$18,904
2. Total annual maintenance cost	23.5 miles @ \$100.00			\$ 2,350
TOTAL ANNUAL COSTS (1 + 2)				\$21,254

b. Average Daily Traffic, 1960

(1) Local Traffic

On the basis of computations at hand we find that there is a possibility of diversion to the routing in the amount of 10 vehicles per day. This being partial construction to Ridgeway, there is no great possibility of a large volume of local diverted traffic. Average daily traffic and travel-distance data are as shown on page 112.

(2) Diverted Traffic

This element of traffic, 6 vehicles per day per mile will be effective over 28.3% of the length of the whole routing.

c. Annual Revenues

As per tabulation shown on page 113.

d. Time Element Savings

As per tabulation which follows:

HIGHWAY PROJECT ANALYSIS

			Time Element Savings
Location of project	MONTANA	County	CARTER
Description of project	EKALAKA-BROADUS ROAD		
Highway number	FAS No. 323	Highway system	FA SECONDARY
Length	23.5 Miles	Date of Analysis	APRIL 1946

LOCAL TRAFFIC AND TRAVEL-DISTANCE DATA AS OF
COMPLETION OF THE EKALAKA-PINELE ROAD SECTION
OF THE EKALAKA-CHALK BUTTES-RIDGEMAY-HAY CREEK-
ALZADA ROUTING

TRAFFIC CLASSIFICATION	EXISTING FACILITIES (Miles)				NEW FACILITIES (Miles)			
	PTW	APPROACH	TOTAL TRAVEL-DISTANCE	NEW	APPROACH	TOTAL TRAVEL-DISTANCE		
	ADT : GRAVEL:UNIMP: OIL : UNIMP	OIL : UNIMP	OIL : GRAVEL:UNIMP:TOTAL:	OIL : GRAVEL:UNIMP: OIL : GRAVEL:UNIMP: TOTAL	OIL : UNIMP	OIL : GRAVEL:UNIMP: OIL : GRAVEL:UNIMP: TOTAL		
Existing Traffic	157	9.2 : 0.05 : 3.4	12.6 : 12.65 : 6.8	0.35	0.05 : 4.25 : 6.85	0.35 : 4.25 : 11.45		
Diverted Traffic	10	2.9 : 8.65 : 4.85	13.5 : 16.4 : 5.95	1.2	9.75 : 5.95 : 1.2	9.75 : 16.9		
Local Traffic	167	0.15 : 9.15 : 0.05 : 3.5	12.65 : 12.85 : 6.75	0.40	0.05 : 4.6 : 6.8	0.4 : 4.6 : 11.8		

HIGHWAY PROJECT ANALYSIS

Traffic Income

Location of project Montana Highway FAS No. 323 Description of project Ekalaka - Broadus Road Length 23.5 miles Date of analysis April 1946 County Carter

Traffic Type	Average Annual Traffic				Average Annual		Unit Net	Total Annual
	Local Traffic		Diverted Traffic		Road use During		Revenues	Net Revenue
	Vehicles	Ton	Vehicles	Ton	Miles	Miles	Per Ton Mi.	
Passenger Cars - Montana	28,653	307,307	1,588	55,927	363,234	\$0.002188	\$	795
Passenger Cars - Foreign	1,204	12,913	273	9,607	22,520	0.001799		41
Total passenger cars	29,857	320,220	1,861	65,534	385,754		\$	836
Trucks, light	24,200	565,808	176	13,506	579,314	0.003248	\$1,882	
Trucks, medium	2,446	120,320	43	6,953	127,273	0.002382	303	
Trucks, heavy	1,350	107,629	6	1,574	109,203	0.001619	177	
Trucks, semi-trailer	1,533	161,783	43	14,892	176,675	0.001543	273	
Trucks, full-trailer	730	119,477	17	9,114	128,591	0.001396	180	
Busses	840	54,054	44	9,302	63,356	0.001873	101	
Total trucks & busses	31,099	1,129,071	329	55,341	1,184,412		\$2,916	
Total all vehicles	60,956	1,449,291	2,190	120,875	1,570,166		\$3,752	

Total Annual Income.....

\$3,752

(Time Element Savings cont'd)

Annual Traffic Volume	Local Traffic		Diverted Traffic	
	New	Old	New	Old
Private Passenger cars (per year)	29,857		1,861	
Trucks, light (per year).....	24,200		176	
Trucks, medium (per year).....	2,446		43	
Trucks, heavy (per year).....	4,453		110	
Totals.....	60,956		2,190	
<u>Private Passenger Cars</u>				
Average speed (miles per hour)...	37.8	30.1	41.2	41.5
Distance (miles).....	11.8	12.85	158.5	227.0
Time (hours per trip).....	0.312	0.427	3.847	5.469
Time savings per vehicle.....	0.115		1.622	
Value of savings (\$/vehicle-hour)	\$0.60		\$0.60	
Annual traffic volume.....	29,857		1,861	
Value of time savings.....			\$1,811	
Total.....	\$ 2,060		\$513, 28.3%	
<u>Trucks, Light</u>				
Average speed (miles per hour)...	34.8	27.1	38.2	38.5
Distance (miles).....	11.8	12.85	158.5	227.0
Time (hours per trip).....	0.339	0.474	4.149	5.896
Time savings per vehicle.....	0.135		1.747	
Value of savings (\$/vehicle-hour)	\$0.86		\$0.86	
Annual traffic volume.....	24,200		176	
Value of time savings.....			\$264	
Total.....	\$ 2,810		\$75, 28.3%	
<u>Trucks, Medium</u>				
Average speed (miles per hour)...	30.8	24.1	34.2	34.5
Distance (miles).....	11.8	12.85	158.5	227.0
Time (hours per trip).....	0.383	0.533	4.635	6.580
Time savings per vehicle.....	0.150		1.945	
Value of savings (\$/vehicle-hour)	\$1.17		\$1.17	
Annual traffic volume.....	2,446		43	
Value of time savings.....			\$98	
Total.....	\$ 429		\$28, 28.3%	
<u>Trucks, Heavy</u>				
Average speed (miles per hour)...	27.8	21.1	31.2	31.5
Distance (miles).....	11.8	12.85	158.5	227.0
Time (hours per trip).....	0.424	0.609	5.080	7.206
Time savings per vehicle.....	0.185		2.126	
Value of savings (\$/vehicle-hour)	\$1.47		\$1.47	
Annual traffic volume.....	4,453		110	
Value of time savings.....			\$344	
Total.....	\$ 1,211		\$97, 28.3%	
Total...each category.....	\$ 6,510		\$713	
TOTAL ANNUAL TIME ELEMENT SAVINGS.....			\$ 7,223	

e. Mileage Element Savings

As per tabulation which follows:

HIGHWAY PROJECT ANALYSIS

		Mileage Element Savings	
Location of project	MONTANA	County	CARTER
Description of Project	EKALAKA-BROADUS ROAD		
Highway number	FAS No. 323	Highway system	FA SECONDARY
Length	23.5 miles	Date of Analysis	APRIL 1946
	Local Traffic		Diverted Traffic
	New	Old	New Old
Distance			
Length (miles).....	11.8	12.85	158.5 227.0
Distance saving (miles).....	1.05		68.5
Average annual traffic (tons)...	202,698		5,146
Annual traffic saving (ton-mi.)..	212,833		352,501

		(Mileage Element Savings cont'd)			
		Local Traffic		Diverted Traffic	
Distance(cont'd)		New	Old	New	Old
Cost (\$/ton-mile).....		\$0.0178		\$0.0196	
Annual saving.....				\$6,909	
Total.....		\$ 3,788		\$1,955,	28.3%
Surface					
Roadway surface type.....		0.133	0.278	0.087	0.077
Saving coefficient.....		0.145		- 0.01	
Aver. annual traffic (ton-mi.).....	2,604,669			1,168,142	
Saving (\$/ton-mile).....		\$0.0026		\$0.002	
Annual Saving.....				- \$234	
Total.....		\$ 6,772		- \$66,	28.3%
Alignment					
Curvature rating.....		6.1	0.15	10.0	9.4
Points improvement.....		5.95		0.6	
Saving (point-ton-miles).....	15,497,781			700,885	
Saving (\$/point-ton-mile).....		\$0.0001		\$0.0001	
Annual saving.....				\$70	
Total.....		\$ 1,550		\$20,	28.3%
Total....each category.....		\$ 12,110		\$1,909	
TOTAL ANNUAL MILEAGE ELEMENT SAVINGS.....		\$ 14,019			

f. Traffic Benefits
As per tabulation which follows:

HIGHWAY PROJECT ANALYSIS

HIGHWAY PROJECT ANALYSIS			Traffic Benefits
Location of project	MONTANA	County	CARTER
Description of project	EKAIA KA-BROADUS ROAD		
Highway number	FAS No. 323	Highway system	FA SECONDARY
Length	23.5 Miles	Date of Analysis	APRIL 1946

Mileage Element Factors

Item			Fuel Function	Non-fuel Function
Distance savings	\$5,743	38%	\$ 2,182	\$ 3,561
Roadway surface savings	6,706	43.5%	2,917	3,789
Alignment Savings	1,570	50%	785	785
Total Mileage Savings	\$14,019		\$ 5,884	\$ 8,135

Time Element Factors

Type of Traffic	Annual Value of Time Savings
Passenger cars	\$ 2,573
Trucks, light	2,885
Trucks, medium	457
Trucks, heavy	1,308
Total Time Savings	\$ 7,223

(Traffic Benefits cont'd)

Recapitulation of Annual Benefits

Total Fuel Function Benefits	\$ 5,884
Non-fuel function (Mileage element factors)	\$ 8,135
benefits (Time element factors)	\$ 7,223
Total Non-fuel Function Benefits	\$15,358
TOTAL ANNUAL BENEFITS	\$21,242

g. Derivation of Quotients

As per tabulation which follows:

HIGHWAY PROJECT ANALYSIS

Location of project	MONTANA	County	CARTER
Description of project	EKALAKA-BROADUS ROAD		
Highway number	FAS No. 323	Highway system	FA SECONDARY
Length	23.5 Miles	Date of analysis	APRIL 1946

$$\begin{aligned}
 I_{ar} &= \$ 3,752 & K_1 &= 1.00 \\
 C_a &= \$ 21,254 & K_2 &= 651/5,884 = 0.11 \\
 B_n &= \$ 15,358 & K_3 &= 0.05/0.20 = 0.25 \\
 B_f &= \$ 5,884 & K_2 K_3 &= 0.11 \times 0.25 = 0.03 \\
 K_1 C_a &= \$ 21,254 & 1 - K_2 K_3 &= 1.00 - 0.03 = 0.97 \\
 Q_s &= I_{ar} / K_1 C_a = 3,752 / 21,254 = 0.175 \\
 Q_{Bn} &= B_n / K_1 C_a = 15,358 / 21,254 = 0.72 \\
 Q_{Bf} &= B_f / K_1 C_a = 5,884 / 21,254 = 0.275 \\
 Q'_s &= Q_s - K_2 K_3 Q_{Bf} = 0.175 - 0.03 \times 0.275 = 0.175 - 0.01 = 0.165 \\
 Q_c &= 0.707 (Q_s / Q_{Bn} / Q_{Bf} (1 - K_2 K_3)) = 0.707 (0.175 / 0.72 / 0.275 \times 0.97) \\
 &= 0.707 (0.175 / 0.72 / 0.265) \\
 &= 0.707 \times 1.16 \\
 &= 0.82
 \end{aligned}$$

Note relatively high value of the composite solvency quotient as pointed out herebefore by reason of the lack of bridge construction expenditures.

2. EKALAKA-RIDGEWAY: Oiled Surface, 19.5 miles; Gravel Surface, 19.5 miles; total distance, 39.0 miles.

a. Annual Cost Calculations

These data are summarized as follows:

Grading 39.0 miles @ \$4,000 per mile.....	\$156,000
Gravel Base and Surface, 39.0 miles @ \$3,500 per mile.....	\$136,500
Minor Drainage Structures, 39.0 miles @ \$800 per mile.....	\$31,200
Oiled Surface, 19.5 miles @ \$2,000 per mile.....	\$39,000
Rights-of-Way	
19.5 miles @ \$500 per mile.....	\$9,750
19.5 miles @ \$400 per mile.....	\$7,800
Engineering and Administration	
Grading, gravel and oil, 19.5 miles @ \$1,000 per mile...	\$19,500
Grading and graveling, 19.5 miles @ \$800 per mile.....	\$15,600
Sub-total.....	\$415,350
✓ 10% for contingencies.....	\$41,535
Total construction costs, 39.0 miles.....	\$456,885

These data are condensed and extended in the tabulation which follows to give indication of the annual capital cost for construction. To this figure has been added a maintenance charge of \$3,900 to arrive at the total annual capital cost of \$33,186.

ANNUAL COST CALCULATIONS

Location of project	MONTANA	County	CARTER
Description of project	EKALAKA-RIDGEWAY		
Highway number	FAS No. 323	Highway system	FA SECONDARY
Length	39.0 Miles	Date of analysis	APRIL 1946

Item	CAPITAL COST			Annual Capital Cost
	Net Cost	Interest Rate	Amort. Period	
Rights of way, easements, etc.	\$ 17,550	2½%	20 Yrs.	\$ 1,125
Clearing, grading, etc.	156,000	"	"	10,000
Pavements and surfacing:				
Type Gravel Base & Surface	136,500	"	"	8,749
Type Oil Surface	39,000	"	"	2,500
Structures:				
Type Minor	31,200	"	"	2,000
Engineering and Administration..	35,100	"	"	2,250
✓ 10% for contingencies.....	41,535	"	"	2,662
1. Total annual capital cost.....				\$ 29,286
2. Total annual maintenance cost	39.0 miles @ \$100.00			\$ 3,900
TOTAL ANNUAL COSTS (1 ✓ 2)				\$ 33,186

b. Average Daily Traffic, 1960

(1) Local Traffic

Average daily traffic and travel-distance data are set forth on page 119. Note the large volume of local traffic which would be diverted to this routing should it be completed through to Ridgeway.

(2) Diverted Traffic

Effective over 47% of the total length of the routing.

c. Annual Revenues

As per tabulation on page 120.

d. Time Element Savings

As per tabulation herebelow.

HIGHWAY PROJECT ANALYSIS

		Time Element Savings	
Location of project	MONTANA	County	CARTER
Description of project	EKALAKA-RIDGEWAY		
Highway number	FAS No. 323	Highway System FA SECONDARY	
Length	39.0 Miles	Date of analysis	APRIL 1946
		Local Traffic	Diverted Traffic @ 47.0%
Annual Traffic Volume		New	Old
Private Passenger cars (per year)	50,443		
Trucks, light (per year).....	40,880		
Trucks, medium (per year).....	4,125		
Trucks, heavy (per year).....	7,482		
Totals.....	102,930		
Private Passenger Cars		New	Old
Average speed (miles per hour)...	37.7	31.0	
Distance (Miles).....	11.95	12.55	
Time (hours per trip).....	0.317	0.405	
Time savings per vehicle.....	0.088		
Value of savings (\$/vehicle-hour)	\$0.60		
Annual traffic volume.....	50,443		
Total.....	\$ 2,663		\$851
Trucks, Light		New	Old
Average speed (miles per hour)...	34.7	28.0	
Distance (miles).....	11.95	12.55	
Time (hours per trip).....	0.344	0.448	
Time savings per vehicle.....	0.104		
Value of savings (\$/vehicle-hour)	\$0.86		
Annual traffic volume.....	40,880		
Total.....	\$ 3,656		\$124
Trucks, Medium		New	Old
Average speed (miles per hour)...	30.7	24.0	
Distance (miles).....	11.95	12.55	
Time (hours per trip).....	0.389	0.523	
Time savings per vehicle.....	0.134		
Value of savings (\$/vehicle-hour)	\$1.17		
Annual traffic volume.....	4,125		
Total.....	\$ 647		\$46

LOCAL TRAFFIC AND TRAVEL-DISTANCE DATA AS OF
 COMPLETION OF THE EKALAKA-RIDGEMAY SECTION OF
 THE EKALAKA-CHALK BUTTES-RIDGEMAY-HAY CREEK
 ALZADA ROUTING

		EXISTING FACILITIES (Miles)				NEW FACILITIES (Miles)			
		PTW		TOTAL TRAVEL-DISTANCE		NEW		TOTAL TRAVEL-DISTANCE	
		OIL:UNIMP:		OIL:GRAVEL:UNIMP:		OIL:GRAVEL:UNIMP:		OIL:GRAVEL:UNIMP:	
		ADT		TOTAL		TOTAL		TOTAL	
		GRAVEL:UNIMP:		OIL:GRAVEL:UNIMP:		OIL:GRAVEL:UNIMP:		OIL:GRAVEL:UNIMP:	
		ADT		TOTAL		TOTAL		TOTAL	
		ADT		TOTAL		TOTAL		TOTAL	
		ADT		TOTAL		TOTAL		TOTAL	
		ADT		TOTAL		TOTAL		TOTAL	
		ADT		TOTAL		TOTAL		TOTAL	
		ADT		TOTAL		TOTAL		TOTAL	
		ADT		TOTAL		TOTAL		TOTAL	
		ADT		TOTAL		TOTAL		TOTAL	
		ADT		TOTAL		TOTAL		TOTAL	
		ADT		TOTAL		TOTAL		TOTAL	
		ADT		TOTAL		TOTAL		TOTAL	
		ADT		TOTAL		TOTAL		TOTAL	
		ADT		TOTAL		TOTAL		TOTAL	
		ADT		TOTAL		TOTAL		TOTAL	
		ADT		TOTAL		TOTAL		TOTAL	
		ADT		TOTAL		TOTAL		TOTAL	
		ADT		TOTAL		TOTAL		TOTAL	
		ADT		TOTAL		TOTAL		TOTAL	
		ADT		TOTAL		TOTAL		TOTAL	
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		ADT		TOTAL		TOTAL			

HIGHWAY PROJECT ANALYSIS

Traffic Income

Location of project Montana Description of project Ekalaka - Ridgeway County Carter
 Highway FAS #323 Highway System FA Secondary Length 39.0 miles Date of analysis April 1946

Traffic Type	Average Annual Traffic				Average Annual			Unit Net	Total Annual
	Local Traffic		Diverted Traffic		Road Use During		Revenues : Net Revenue		
	Vehicles	Ton	Vehicles	Ton	Life of Project	Per Ton Mi.			
		Miles		Miles		Ton Mi.			
Passenger Cars - Montana	48,399	566,272	1,588	92,883	659,155	\$0.002188	\$1,442		
Passenger Cars - Foreign	2,044	23,915	273	15,955	39,870	0.001799	72		
Total passenger cars	50,443	590,187	1,861	108,838	699,025		\$1,514		
Trucks, light	40,880	1,042,688	176	22,430	1,065,118	0.003248	\$3,460		
Trucks, medium	4,125	221,364	43	11,547	232,911	0.002382	555		
Trucks, heavy	2,263	196,810	6	2,614	199,424	0.001619	323		
Trucks, semi-trailer	2,591	298,295	43	24,732	323,027	0.001543	498		
Trucks, full-trailer	1,241	221,567	17	15,136	236,703	0.001396	330		
Busses, other	1,387	97,367	44	15,448	112,815	0.001873	211		
Total trucks & busses	52,487	2,078,091	329	91,907	2,169,998		\$5,377		
Total all vehicles	102,930	2,668,278	2,190	200,745	2,869,023		\$6,891		

Total Annual Income..... \$6,891

(Time Element Savings cont'd)				
	Local Traffic		Diverted Traffic	
			@ 47.0%	
Trucks, Heavy	New	Old	New	Old
Average speed (miles per hour).....	27.7	21.0		
Distance (miles).....	11.95	12.55		
Time (hours per trip).....	0.431	0.600		
Time savings per vehicle.....	0.169			
Value of savings (\$/vehicle-hour)...	\$1.47			
Annual traffic volume.....	7,482			
Total.....	\$ 1,859		\$162	
Total.....each category.....	\$ 8,825		\$1,183	
TOTAL ANNUAL TIME ELEMENT SAVINGS.....			\$ 10,008	

e. Mileage Element Savings
As per tabulation hereinafter

HIGHWAY PROJECT ANALYSIS

		Mileage Element Savings			
Location of project	MONTANA	County	CARTER		
Description of Project	EKALAKA-RIDGEWAY				
Highway number	FAS No. 323	Highway system	FA SECONDARY		
Length	39.0 miles	Date of Analysis	APRIL 1946		
		Local Traffic	Diverted Traffic		
			@ 47%		
Distance		New	Old	New	Old
Length (miles).....		11.95	12.55		
Distance saving (miles).....		0.6			
Average annual traffic (tons).....		342,087			
Annual traffic saving (ton-mi.).....		205,252			
Cost (\$/ton-mile).....		\$0.0178			
Total.....		\$ 3,652		\$ 3,247	
Surface					
Roadway surface type.....		0.144	0.267		
Saving coefficient.....		0.123			
Aver. annual traffic (ton-mi.).....		4,430,027			
Saving (\$/ton-mile).....		\$0.002			
Total.....		\$ 8,860		- \$110	
Alignment					
Curvature rating.....		6.5	1.1		
Points improvement.....		5.4			
Saving (point-ton-miles).....		23,922,146			
Saving(\$/point-ton-mile).....		\$0.0001			
Total.....		\$ 2,392		\$33	
Total.....each category.....		\$ 14,904		\$3,170	
TOTAL ANNUAL MILEAGE ELEMENT SAVINGS.....				\$ 18,074	

f. Traffic Benefits
As per tabulation hereinafter.

HIGHWAY PROJECT ANALYSIS

Traffic Benefits

Location of project MONTANA County CARTER
 Description of project EKALAKA-RIDGEWAY
 Highway number FAS No. 323 Highway system FA SECONDARY
 Length 39.0 miles Date of analysis April 1946

Mileage Element Factors

Item			Fuel Function	Non-fuel Function
Distance savings	\$6,899	38%	\$ 2,622	\$ 4,277
Roadway surface savings	8,750	44.5%	3,894	4,856
Alignment savings	2,425	50%	1,213	1,212
Total Mileage Savings	\$18,074		\$ 7,729	\$10,345

Time Element Factors

Type of Traffic	Annual Value of Time Savings
Passenger cars	\$ 3,514
Trucks, light	3,780
Trucks, medium	693
Trucks, heavy	2,021
Total Time Savings	\$ 10,008

Recapitulation of Annual Benefits

Total Fuel Function Benefits	\$ 7,729
Non-fuel function (Mileage element factors	\$ 10,345
benefits (Time element factors	\$ 10,008
Total Non-fuel Function Benefits	\$ 20,353
TOTAL ANNUAL BENEFITS	\$ 28,082

g. Derivation of Quotients
 As per tabulation herinafter.

HIGHWAY PROJECT ANALYSIS

Location of project MONTANA County CARTER
 Description of project EKALAKA-RIDGEWAY
 Highway number FAS No. 323 Highway system FA SECONDARY
 Length 39.0 Miles Date of Analysis April 1946

$I_{ar} = \$ 8,837$ $K_1 = 1.00$
 $C_a = \$ 33,186$ $K_2 = 1,201/7,729 = 0.155$
 -122-

(Derivation of Quotients cont'd)

$$\begin{aligned}
 B_n &= \$ 20,353 & K_3 &= 0.05/0.20 = 0.25 \\
 B_f &= \$ 7,729 & K_2 K_3 &= 0.14 \times 0.25 = 0.04 \\
 K_1 C_a &= \$ 33,186 & 1-K_2 K_3 &= 1.00 - 0.04 = 0.96 \\
 Q_s &= I_{ar}/K_1 C_a = 8,837/33,186 = 0.265 \\
 Q_{Bn} &= B_n/K_1 C_a = 20,353/33,186 = 0.615 \\
 Q_{Bf} &= B_f/K_1 C_a = 7,729/33,186 = 0.23 \\
 Q'_s &= Q_s - K_2 K_3 Q_{Bf} = 0.265 - 0.04 \times 0.23 = 0.265 - 0.01 = 0.255 \\
 Q_c &= 0.707 (Q_s/Q_{Bn} + Q_{Bf}(1-K_2 K_3)) = 0.707 (0.265/0.615 + 0.23 \times 0.96) \\
 &= 0.707 (0.265/0.615 + 0.22) \\
 &= 0.707 \times 1.10 \\
 &= 0.78
 \end{aligned}$$

Note the continued high level of solvency, relatively speaking, this by reason of the fact that no expenditures for bridge construction will be necessary to build this routing to this point.

3.EKALAKA-ALBION ROAD: Oiled Surface 19.5, miles; gravel surface, 22.5 miles; total distance, 42.0 miles.

a. Annual Cost Calculations

Construction costs are summarized as follows:

Grading, 42.0 miles @ \$4,000 per mile.....	\$168,000
Gravel Base and Surface, 42.0 miles @ \$3,500 per mile.....	\$147,000
Major Drainage Structures, bridges, 2 timber, 120 feet @ \$100 per lineal foot.....	\$12,000
Minor Drainage Structures, 42.0 miles @ \$800 per mile.....	\$33,600
Oiled Surface, 19.5 miles @ \$2,000 per mile.....	\$39,000
Rights-of-Way 19.5 miles @ \$500 per mile.....	\$9,750
22.5 miles @ \$400 per mile.....	\$9,000
Engineering and Administration Grading, gravel, and oil, 19.5 miles @ \$1,000 per mile....	\$19,500
Grade and gravel, 22.5 miles @ \$800 per mile.....	\$18,000
Bridges, 5% of \$12,000.....	\$600

Sub-total..... \$456,450

✓ 10% for contingencies..... \$45,645

Total construction cost, 42.0 miles..... \$502,095

These data are resolved along with estimated maintenance costs to arrive at a total annual capital cost in the tabulation which follows:

ANNUAL COST CALCULATIONS

Location of project	MONTANA	County	CARTER
Description of project	EKALAKA-ALBION ROAD		
Highway number	FAS No. 323	Highway system	FA SECONDARY
Length	42.0 miles	Date of analysis	APRIL 1946

	CAPITAL COSTS			Annual
Item	Net Cost	Interest Rate	Amort. Period	Capital Cost
Rights of way, easements, etc.	\$ 18,750	2 $\frac{1}{2}$ %	20 yrs.	\$ 1,202
Clearing, grading, etc.	<u>168,000</u>	"	"	<u>10,769</u>
Pavements and surfacing:				
Type Gravel Base & Surface	147,000	"	"	9,423
Type Oil Surface	<u>39,000</u>	"	"	<u>2,500</u>
Structures:				
Type Major, 2 Timber	12,000	"	"	769
Type Minor	<u>33,600</u>	"	"	<u>2,154</u>
Engineering and Administration..	38,100	"	"	2,442
✓ 10% for contingencies.....	<u>45,645</u>	"	"	<u>2,926</u>
1. Total annual capital cost.....				<u>\$ 32,185</u>
2. Total annual maintenance cost.....	42.0 miles @ \$100.00			<u>\$ 4,200</u>
TOTAL ANNUAL COSTS (1 ✓ 2)				<u>\$ 36,385</u>

b. Average Daily Traffic, 1960

(1) Local Traffic

Average daily traffic and travel-distance data are as shown on page 125.

(2) Diverted Traffic

Effective in the amount of 6 vehicles per day per mile over 50.6% of the total length of the routing.

c. Annual Revenues

As per tabulation shown on page 126.

d. Time Element Savings

As per tabulation which follows:

LOCAL TRAFFIC AND TRAVEL-DISTANCE DATA AS OF
COMPLETION OF THE EKALAKA-ALBION ROAD SECTION
OF THE EKALAKA-CHALK BUTTES-RIDGEMAY-HAY CREEK
(PINIELE ROAD TURNOFF) - ALZADA ROUTING

		EXISTING FACILITIES (Miles)				NEW FACILITIES (Miles)			
TRAFFIC		PTW	APPROACH	TOTAL TRAVEL-DISTANCE	NEW	APPROACH	TOTAL TRAVEL-DISTANCE		
CLASSIFICATION									
	ADT	GRAVEL:UNIMP	OIL:UNIMP	OIL:GRAVEL:UNIMP:TOTAL	OIL:GRAVEL:UNIMP:TOTAL	OIL:GRAVEL:UNIMP:TOTAL	OIL:GRAVEL:UNIMP:TOTAL		
Existing Traffic	222	9.6	0.15:10.35	0.15:	19.95:20.1	4.8	1.95	0.15:12.35	4.95: 1.95 :12.35:19.25:
Diverted Traffic	132	1.65	5.3	0.5	1.95: 0.5 : 1.65 : 7.25: 9.4	3.35	3.4	0.5 : 2.35: 3.85: 3.4	2.35: 9.6 :
Local Traffic	354	0.6	8.0	0.3	7.2 : 0.3 : 0.6 : 15.2 : 16.1	4.25	2.5	0.3 : 8.6 : 4.55: 2.5	8.6 :15.65:

HIGHWAY PROJECT ANALYSIS

Traffic Income

Location of project Montana Description of project Ekalaka - Albion Road County Carter
 Highway FAS No. 323 Highway System FA Secondary Length 42.0 Miles Date of analysis April 1946

Traffic Type	Average Annual Traffic				Average Annual		Unit Net	Total Annual
	Local Traffic		Diverted Traffic		Road Use During		Revenues	Net Revenue
	Vehicles	Ton	Vehicles	Ton	Life of Project	Per Ton Mi		
		Miles		Miles	Ton Mile			
: Passenger Cars - Montana	: 60,736	: 614,952:	: 1,588	: 99,997	: 714,949	: \$0.002188	:	: \$1,564
: Passenger Cars - Foreign	: 2,591	: 26,237:	: 273	: 17,177	: 43,414	: 0.001799	:	: 78
: Total passenger cars	: 63,327	: 641,189:	: 1,861	: 117,174	: 758,363	:	:	: \$1,642
: Trucks, light	: 51,283	: 1,131,941:	: 176	: 24,149	: 1,156,090	: 0.003248	:	: \$3,755
: Trucks, medium	: 5,183	: 240,698:	: 43	: 12,431	: 253,129	: 0.002382	:	: 603
: Trucks, heavy	: 2,847	: 214,272:	: 6	: 2,814	: 217,086	: 0.001619	:	: 351
: Trucks, semi-trailer	: 3,212	: 320,011:	: 43	: 26,627	: 346,638	: 0.001543	:	: 535
: Trucks, full-trailer	: 1,533	: 236,857:	: 17	: 16,295	: 253,152	: 0.001396	:	: 353
: Busses	: 1,825	: 110,869:	: 44	: 16,631	: 127,500	: 0.001873	:	: 239
: Total trucks & busses	: 65,883	: 2,254,648:	: 329	: 98,947	: 2,353,595	:	:	: \$5,836
: Total all vehicles	: 129,210	: 2,895,837:	: 2,190	: 216,121	: 3,111,958	:	:	: \$7,478

Total Annual Income.....\$7,478

HIGHWAY PROJECT ANALYSIS

Time Element Savings

Location of project	MONTANA	County	CARTER
Description of project	EKALAKA-ALBION ROAD		
Highway number	FAS No. 323	Highway system	FA SECONDARY
Length	42.0 Miles	Date of analysis	APRIL 1946
	Local Traffic	Diverted Traffic @ 50.6%	
Annual Traffic Volume	New	Old	New Old
Private Passenger cars (per year)	63,327		
Trucks, light (per year).....	51,283		
Trucks, medium (per year).....	5,183		
Trucks, heavy (per year).....	9,417		
Totals.....	129,210		
Private Passenger Cars			
Average speed (miles per hour)...	35.1	30.5	
Distance (miles).....	15.65	16.1	
Time (hours per trip).....	0.446	0.528	
Time savings per vehicle.....	0.082		
Value of savings (\$/vehicle-hour)	\$0.60		
Annual traffic volume.....	63,327		
Totals.....	\$ 3,116		\$916
Trucks, Light			
Average speed (miles per hour)...	32.1	27.5	
Distance (miles).....	15.65	16.1	
Time (hours per trip).....	0.487	0.585	
Time savings per vehicle.....	0.098		
Value of savings (\$/vehicle-hour)	\$0.86		
Annual traffic volume.....	51,283		
Totals.....	\$ 4,322		\$134
Trucks, Medium			
Average speed (miles per hour)...	28.1	23.5	
Distance (miles).....	15.65	16.1	
Time (hours per trip).....	0.557	0.685	
Time savings per vehicle.....	0.128		
Value savings (\$/vehicle-hour)...	\$1.17		
Annual traffic volume.....	5,183		
Totals.....	\$ 776		\$50
Trucks, Heavy			
Average speed (miles per hour)...	25.1	20.5	
Distance (miles).....	15.65	16.1	
Time (hours per trip).....	0.624	0.785	
Time savings per vehicle.....	0.161		
Value of savings (\$/vehicle-hour)	\$1.47		
Annual traffic volume.....	9,417		
Totals.....	\$ 2,229		\$174
Total.....each category.....	\$ 10,443		\$1,274
TOTAL ANNUAL TIME ELEMENT SAVINGS.....			\$ 11,717

e. Mileage Element Savings

As per tabulation which follows:

HIGHWAY PROJECT ANALYSIS

Mileage Element Savings

Location of project	MONTANA	County	CARTER	
Description of Project	EKALAKA-ALBION ROAD			
Highway number	FAS No. 323	Highway system	FA SECONDARY	
Length	42.0 Miles	Date of analysis	APRIL 1946	
	Local Traffic	Diverted Traffic		
		@ 50.6%		
Distance	New	Old	New	Old
Length (miles).....	15.65	16.1		
Distance saving(miles).....	0.45			
Average annual traffic (tons)....	429,013			
Annual traffic saving (ton-mi.)..	193,056			
Cost (\$/ton-mile).....	\$0.0178			
Total.....	\$ 3,436		\$3,496	
Surface				
Roadway surface type.....	0.193	0.271		
Saving coefficient.....	0.078			
Aver. annual traffic (ton-mi.)...	6,907,109			
Saving (\$/ton-mile).....	\$0.0014			
Total.....	\$ 9,670		- \$118	
Alignment				
Curvature rating.....	4.5	0.6		
Points improvement.....	3.9			
Saving (point-ton-miles).....	26,937,725			
Saving (\$/point-ton-mile).....	\$0.0001			
Total.....	\$ 2,694		\$35	
Total....each category....	\$ 15,800		\$3,413	
TOTAL ANNUAL MILEAGE ELEMENT SAVINGS.....			\$ 19,213	

f. Traffic Benefits

As per tabulation which follows

HIGHWAY PROJECT ANALYSIS

Traffic Benefits

Location of project	MONTANA	County	CARTER
Description of project	EKALAKA-ALBION ROAD		
Highway number	FAS NO. 323	Highway system	FA SECONDARY
Length	42.0 Miles	Date of analysis	APRIL 1946

Mileage Element Factors

Item			Fuel Function	Non-fuel Function
Distance savings	\$6,932	38%	\$ 2,634	\$ 4,298
Roadway surface savings	9,552	44.5%	4,251	5,301
Alignment savings	2,729	50%	1,365	1,364
Total Mileage Savings	\$19,213		\$ 8,250	\$ 10,963

(Traffic Benefits cont'd)

<u>Time Element Factors</u>	
Type of Traffic	Annual Value of Time Savings
Passenger cars	\$ 4,032
Trucks, light	4,456
Trucks, medium	826
Trucks, heavy	2,403
Total Time Savings	\$ 11,717

Recapitulation of Annual Benefits

Total Fuel Function Benefits	\$ 8,250
Non-fuel function (Mileage element factors	\$ 10,963
benefits (Time element factors	\$ 11,717
Total Non-fuel Function Benefits	\$ 22,680
TOTAL ANNUAL BENEFITS	\$ 30,930

g. Derivation of Quotients
As per tabulation which follows:

HIGHWAY PROJECT ANALYSIS

Location of project	MONTANA	County	CARTER
Description of project	EKALAKA-ALBION ROAD		
Highway number	FAS No. 323	Highway system	FA SECONDARY
Length	42.0 miles	Date of analysis	April 1946

$I_{ar} = \$$	7,478	K_1	$= 1.00$
$C_a = \$$	36,385	K_2	$= 1,293/8,250 = 0.155$
$B_n = \$$	22,680	K_3	$= 0.05/0.20 = 0.25$
$B_f = \$$	8,250	$K_2 K_3$	$= 0.155 \times 0.25 = 0.04$
$K_1 C_a = \$$	36,385	$1 - K_2 K_3$	$= 1.00 - 0.04 = 0.96$
$Q_s = I_{ar} / K_1 C_a =$	$7,478 / 36,385 = 0.205$		
$Q_{Bn} = B_n / K_1 C_a =$	$22,680 / 36,385 = 0.625$		
$Q_{Bf} = B_f / K_1 C_a =$	$8,250 / 36,385 = 0.225$		
$Q'_s = Q_s - K_2 K_3 Q_{Bf} =$	$0.205 - 0.04 \times 0.225 = 0.205 - 0.01 = 0.195$		

(Derivation of Quotients cont'd)

$$\begin{aligned} Q_0 &= 0.707 (Q_s / Q_{Bn} / Q_{Bf} (1 - K_2 K_3)) = 0.707 (0.205 / 0.625 / 0.225 \times 0.96) \\ &= 0.707 (0.205 / 0.625 / 0.24) \\ &= 0.707 \times 1.07 \\ &= 0.755 \end{aligned}$$

Note that the composite solvency quotient developed to this point in this series of analyses is the same as that computed in Analysis A, subsection 3, g.

4. EKALAKA-PINIELE ROAD: Oiled Surface, 19.5 miles; Gravel Surface, 33.0 mile; total distance, 52.5 miles.

a. Annual Cost Calculations

Construction costs are summarized as follows:

Grading, 52.5 miles @ \$4,000 per mile.....	\$210,000
Gravel Base and Surface, 52.5 miles @ \$3,500 per mile.....	\$183,750
Major Drainage Structures, bridges	
5 Timber, 300 feet @ \$100 per lineal foot.....	\$30,000
Minor Drainage Structures, 52.5 miles @ \$800 per mile.....	\$42,000
Oiled Surface, 19.5 miles @ \$2,000 per mile.....	\$39,000
Rights-of-Way	
19.5 miles @ \$500 per mile.....	\$9,750
33.0 miles @ \$400 per mile.....	\$13,200
Engineering and Administration	
Grading, gravel, and oil 19.5 miles @ \$1,000 per mile...	\$19,500
Grading and gravel, 33.0 miles @ \$800 per mile.....	\$26,400
Bridges, 5% of \$30,000	\$1,500
Sub-total.....	\$575,100
/ 10% for contingencies.....	\$57,510

Total construction costs, 52.5 miles..... \$632,610

These data are summarized and extended along with annual maintenance costs to arrive at the total annual capital costs in the tabulation which follows:

ANNUAL COST CALCULATIONS

Location of project	MONTANA	County	CARTER
Description of project	EKALAKA-PINIELE ROAD		
Highway number	FAS No. 323	Highway system	FA SECONDARY
Length	52.5 Miles	Date of analysis	April 1946

CAPITAL COSTS				Annual
Item	Net Cost	Interest Rate	Amort. Period	Capital Cost
Rights of way, easements, etc.	\$ 22,950	2 1/2%	20 yrs.	\$ 1,471
Clearing, grading, etc.	210,000	"	"	13,461
Pavements and surfacing:				
Type Gravel Base & Surface	183,750	"	"	11,778
Type Oil Surface	39,000	"	"	2,500
Structures:				
Type Major, 5 Timber	30,000	"	"	1,923
Type Minor	42,000	"	"	2,692
Engineering & Administration.....	47,400	"	"	3,038
✓ 10% for contingencies.....	57,510	"	"	3,686
1. Total annual capital cost.....				\$ 40,549
2. Total annual maintenance cost	52.5 miles @ \$100.00			\$ 5,250
TOTAL ANNUAL COSTS (1 + 2)				\$ 45,799

b. Average Daily Traffic

(1) Local Traffic

Average daily traffic and travel-distance data are as shown on page 132.

(2) Diverted Traffic

This element of traffic, 6 vehicles per day per mile, will be effective over 63.3% of the total length of the routing.

c. Annual Revenues

As per tabulation shown on page 133.

d. Time Element Savings

As per tabulation which follows:

HIGHWAY PROJECT ANALYSIS

Time Element Savings

Location of project	MONTANA	County	CARTER
Description of project	EKALAKA-PINIELE ROAD		
Highway number	FAS No. 323	Highway system	FA SECONDARY
Length	52.5 miles	Date of Analysis	April 1946
		Local Traffic	Diverted Traffic
			@ 63.3%
Annual Traffic Volume	New	Old	New
Private Passenger cars (per year)	62,415		
Trucks, light (per year).....	50,589		
Trucks, medium (per year).....	5,110		
Trucks, heavy (per year).....	9,271		
Totals.....	127,385		

LOCAL TRAFFIC AND TRAVEL-DISTANCE DATA AS OF COMPLETION
OF THE EKALAKA-PINIELE ROAD SECTION OF THE EKALAKA -
CHALK BUTTES - RIDGEWAY - HAY CREEK - ALZADA ROUTING

		EXISTING FACILITIES (Miles)				NEW FACILITIES (Miles)			
		PTW				NEW			
		APPROACH				APPROACH			
		TOTAL TRAVEL-DISTANCE				TOTAL TRAVEL-DISTANCE			
		OIL : UNIMP :				OIL : UNIMP :			
		GRAVEL : TOTAL :				GRAVEL : TOTAL :			
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HIGHWAY PROJECT ANALYSIS

Traffic Income

Location of project Montana Description of project Ekalaka-Pinielle Road County Carter
 Highway FAS No. 323 Highway System FA Secondary Length 52.5 miles Date of analysis April 1946

Traffic Type	Average Annual Traffic		Diverted Traffic		Average Annual		Unit Net		Total Annual
	Local Traffic	Foreign	Vehicles	Ton	Vehicles	Ton	Road Use During	Revenues	
	Vehicles	Ton	Miles	Miles	Vehicles	Ton	Life of Project	Per Ton Mi.	
Passenger Cars - Montana	89,790	691,383	1,588	125,095	816,478	\$0.002188	\$1,786		
Passenger Cars - Foreign	3,833	29,514	273	21,488	51,002	0.001799	92		
Total passenger cars	93,623	720,897	1,861	146,583	867,480		\$1,878		
Trucks, light	165,426	1,273,780	176	30,210	1,303,990	0.003248	4,235		
Trucks, medium	35,157	270,709	43	15,552	286,261	0.002382	682		
Trucks, heavy	31,343	241,341	6	3,520	244,861	0.001619	396		
Trucks, semi-trailer	46,863	360,845	43	33,310	394,155	0.001543	608		
Trucks, full-trailer	35,090	270,193	17	20,385	290,578	0.001396	406		
Busses	15,768	121,414	44	20,805	142,219	0.001873	266		
Total trucks & busses	329,647	2,538,282	329	123,782	2,662,064		\$6,593		
Total all vehicles	423,270	3,259,179	2,190	270,365	3,529,544		\$8,471		

Total Annual Income.....\$8,471

(Time Element Savings cont'd)
Local Traffic Diverted Traffic
 @ 63.3%

Private Passenger Cars		New	Old	New	Old
Average speed (miles per hour) ..		35.3	30.6		
Distance (miles)		16.7	17.2		
Time (hours per trip)		0.473	0.562		
Time savings per vehicle		0.089			
Value of savings (\$/vehicle-hour)		\$0.60			
Annual traffic volume		62,415			
Total		\$ 3,333		\$1,146	
Trucks, Light					
Average speed (miles per hour) ..		32.3	27.6		
Distance (miles)		16.7	17.2		
Time (hours per trip)		0.517	0.623		
Time savings per vehicle		0.106			
Value of savings (\$/vehicle-hour)		\$0.86			
Annual traffic volume		50,589			
Total		\$ 4,612		\$167	
Trucks, Medium					
Average speed (miles per hour) ..		28.3	23.6		
Distance (miles)		16.7	17.2		
Time (hours per trip)		0.590	0.729		
Time savings per vehicle		0.139			
Value of savings (\$/vehicle-hour)		\$1.17			
Annual traffic volume		5,110			
Total		\$831		\$62	
Trucks, Heavy					
Average speed (miles per hour) ..		25.3	20.6		
Distance (miles)		16.7	17.2		
Time (hours per trip)		0.680	0.835		
Time savings per vehicle		0.175			
Value of savings (\$/vehicle-hour)		\$1.47			
Annual traffic volume		9,271			
Total		\$ 2,385		\$218	
Total...each category		\$ 11,161		\$1,593	
TOTAL ANNUAL TIME ELEMENT SAVINGS				\$ 12,754	

e. Mileage Element Savings
As per tabulation which follows:

HIGHWAY PROJECT ANALYSIS

		Mileage Element Savings	
Location of project	MONTANA	County	CARTER
Description of project	EKALAKA-PINIELE ROAD		
Highway number	PAS No. 323	Highway system	FA SECONDARY
Length	52.5 miles	Date of analysis	APRIL 1946
		Local Traffic	Diverted Traffic @ 63.3%
Distance		New	Old
Length (miles)		16.7	17.2
Distance saving (miles)		0.5	

(Mileage Element Savings cont'd)				
Distance (cont'd)	Local Traffic		Diverted Traffic @ 63.3%	
	New	Old	New	Old
Average annual traffic (tons).....	423,270			
Annual traffic saving (ton-mi.)...	211,635			
Cost (\$/ton-mile).....	\$0.0178			
Total.....	\$ 3,767		\$4,373	
Surface				
Roadway surface type.....	0.191	0.271		
Saving coefficient.....	0.08			
Aver. annual traffic (ton-mile)...	7,280,244			
Saving (\$/ton-mile).....	\$0.0014			
Total.....	\$ 10,192		- \$148	
Alignment				
Curvature rating.....	4.35	0.6		
Points improvement.....	4.25			
Saving (point-ton-miles).....	30,941,037			
Saving (\$/point-ton-mile).....	\$0.0001			
Total.....	\$ 3,094		\$44	
Total...each category.....	\$ 17,053		\$4,269	
TOTAL ANNUAL MILEAGE ELEMENT SAVINGS.....			\$ 21,322	

f. Traffic Benefits

As per tabulation which follows:

HIGHWAY PROJECT ANALYSIS

			Traffic Benefits	
Location of project	MONTANA	County	CARTER	
Description of project	EKALAKA-PINIELE ROAD			
Highway number	FAS No. 323	Highway system	FA SECONDARY	
Length	52.5 miles	Date of analysis	APRIL 1946	

Mileage Element Factors

Item			Fuel Function	Non-fuel Function
Distance savings	\$8,140	38%	\$ 3,093	\$ 5,047
Roadway surface savings	10,044	44.5%	4,470	5,574
Alignment savings	3,138	50%	1,569	1,569
Total Mileage Savings	\$21,322		\$ 9,132	\$ 12,190

Time Element Factors

Type of Traffic	Annual Value of Time Savings
Passenger cars	\$ 4,479
Trucks, light	4,779
Trucks, medium	893

Traffic Benefits (cont'd)

Trucks, heavy _____ \$ 2,603

Total Time Savings \$ 12,754

Recapitulation of Annual Benefits

Total Fuel Function Benefits _____ \$ 9,132

Non-fuel function (Mileage element factors \$ 12,190
benefits (Time element factors \$ 12,754

Total Non-fuel Function Benefits _____ \$ 24,944

TOTAL ANNUAL BENEFITS _____ \$ 34,076

g. Derivation of Quotients
As per tabulation which follows:

HIGHWAY PROJECT ANALYSIS

Location of project _____ MONTANA _____ County _____ CARTER
Description of project _____ EKALAKA-PINIELE ROAD
Highway number _____ FAS No. 323 _____ Highway system FA SECONDARY
Length _____ 52.5 miles _____ Date of analysis APRIL 1946

$I_{ar} = \$ 8,471$ $K_1 = 1.00$

$C_a = \$ 45,799$ $K_2 = 1,618/9,132 = 0.175$

$B_n = \$ 24,944$ $K_3 = 0.05/0.20 = 0.25$

$B_f = \$ 9,132$ $K_2 K_3 = 0.175 \times 0.25 = 0.045$

$K_1 C_a = \$ 45,799$ $1 - K_2 K_3 = 1.00 - 0.045 = 0.955$

$Q_s = I_{ar}/K_1 C_a = 8,471/45,799 = 0.185$

$Q_{Bn} = B_n/K_1 C_a = 24,944/45,799 = 0.545$

$Q_{Bf} = B_f/K_1 C_a = 9,132/45,799 = 0.20$

$Q'_s = Q_s - K_2 K_3 Q_{Bf} = 0.185 - 0.045 \times 0.70 = 0.185 - 0.01 = 0.175$

$Q_o = 0.707 (Q_s/Q_{Bn}/Q_{Bf}(1 - K_2 K_3)) = 0.707 (0.185 / 0.545 / 0.20 \times 0.955)$

$= 0.707 (0.185 / 0.545 / 0.19)$

$= 0.707 \times 0.92$

$= 0.65$

Note that the composite solvency quotient is, for all practical purposes, identical with that developed in Analysis A, sub-section 4, g.

5. EKALAKA-US 212: Oiled Surface, 19.5 miles: Gravel Surface, 56.5 miles; total travel-distance, 76.0 miles.

a. Annual Cost Calculations

Details of construction costs are summarized as follows:

Grading, 76.0 miles @ \$4,000 per mile.....	\$304,000
Gravel Base and Surface, 76.0 miles @ \$3,500 per mile.....	\$266,000
Major Drainage Structures, bridges	
1 Steel, 100 feet @ \$150 per lineal foot.....	\$15,000
7 Timber, 420 feet @ \$100 per lineal foot.....	\$42,000
Minor Drainage Structures, 76.0 miles @ \$800 per mile.....	\$60,800
Oiled Surface, 19.5 miles @ \$2,000 per mile.....	\$39,000
Rights-of-Way	
19.5 miles @ \$500 per mile.....	\$9,750
56.5 miles @ \$400 per mile.....	\$22,600
Engineering and Administration	
Grading, gravel and oil, 19.5 miles @ \$1,000 per mile....	\$19,500
Grade and gravel 56.5 miles @ \$800 per mile.....	\$45,200
Bridges, 5% of \$57,000.....	<u>\$2,850</u>
Sub-total.....	\$826,700
+ 10% for contingencies.....	<u>\$82,670</u>
Total construction costs, 76.0 miles.....	\$909,370

These data are extended on the tabulation which follows to cover the application of interest charges and then combined with estimated maintenance costs to arrive at a total annual capital cost.

ANNUAL COST CALCULATIONS

Location of project	MONTANA	County	CARTER
Description of project	EKALAKA - US 212		
Highway number	FAS No. 323	Highway system	FA SECONDARY
Length	76.0 miles	Date of analysis	APRIL 1946

Item	CAPITAL COST			Annual Capital Cost
	Net Cost	Interest Rate	Amort. Period	
Rights of way, easements, etc.	\$ 32,350	2 $\frac{1}{2}$ %	20 yrs.	\$ 2,073
Clearing, grading, etc.	<u>304,000</u>	"	"	<u>19,486</u>
Pavements and surfacing:				
Type <u>Gravel Base & Surface</u>	<u>266,000</u>	"	"	<u>17,051</u>

		(Annual Cost Calculations cont'd)			
Type	Oil Surface	\$ 39,000	2 $\frac{1}{2}$ %	20 yrs.	\$ 2,500
Structures:					
Type	Major, 1 Steel	15,000	"	"	962
Type	Major, 7 Timber	42,000	"	"	2,692
Type	Minor	60,800	"	"	3,897
Engineering and Administration		67,550	"	"	4,330
/ 10% for contingencies.....		82,670	"	"	5,299

1. Total annual capital cost.....\$ 58,290

2. Total annual maintenance cost 76.0 mi. @ \$100.00 \$ 7,600

TOTAL ANNUAL COSTS (1 / 2) \$ 65,890

b. Average Daily Traffic, 1960

(1) Local Traffic

Average daily traffic and travel-distance data are as shown on page 139.

(2) Diverted Traffic

This element of traffic will be effective over 91.6% of the total length of the routing.

c. Annual Revenues

As per tabulation shown on page 140.

d. Time Element Savings

As per tabulation which follows:

HIGHWAY PROJECT ANALYSIS

		Time Element Savings	
Location of project	MONTANA	County	CARTER
Description of project	EKALAKA-US 212		
Highway number	FAS No. 323	Highway system	FA SECONDARY
Length	76.0 miles	Date of analysis	April 1946
		Local Traffic	Diverted Traffic
			@ 91.6%
Annual Traffic Volume		New	Old
Private Passenger Cars (per year)		76,906	
Trucks, light (per year).....		62,306	
Trucks, medium(per year).....		6,278	
Trucks, heavy (per year).....		11,461	
Totals.....		156,951	
Private Passenger Cars			
Average speed (miles per hour)...		36.1	32.0
Distance (miles).....		17.35	18.4
Time (hours per trip).....		0.481	0.575
Time savings per vehicle.....		0.094	
Value of savings (\$/vehicle-hour)		\$0.60	
Annual traffic volume.....		76,906	
Total.....		\$ 4,337	\$1,659

HIGHWAY PROJECT ANALYSIS

Location of project	Montana	Description of project	Ekalaka - US 212
Highway	FAS No. 323	Highway System	FA Secondary
		Length	76.0 miles
		Date of analysis	April 1946

Traffic Income
County Carter

Traffic Type	Average Annual Traffic				Average Annual		Unit Net		Total Annual
	Local Traffic		Diverted Traffic		Road Use During		Revenues		
	Vehicles	Ton	Vehicles	Ton	Life of Project	Per Ton Mi:	Revenues	Net Revenue	
		Miles		Miles		Ton Mile			
Passenger Cars - Montana	73,767	:1,017,980:	1,588	:181,023:	1,199,003	:\$0.002188:		\$ 2,623	
Passenger Cars - Foreign	3,139	:43,323:	273	:31,095:	74,418	:0.001799:		134	
Total passenger cars	76,906	:1,061,303:	1,861	:212,118:	1,273,421	:		\$ 2,757	
Trucks, light	62,306	:1,874,417:	176	:43,716:	1,918,133	:0.003248:		\$ 6,230	
Trucks, medium	6,278	:397,376:	43	:22,504:	419,880	:0.002382:		1,000	
Trucks, heavy	3,467	:355,644:	6	:5,094:	360,738	:0.001619:		584	
Trucks, semi-trailer	3,906	:530,408:	43	:48,202:	578,610	:0.001543:		893	
Trucks, full-trailer	1,898	:399,694:	17	:29,499:	429,193	:0.001396:		599	
Busses, other	2,190	:181,332:	44	:30,107:	211,439	:0.001873:		396	
Total trucks & busses	80,045	:3,738,871:	329	:179,122:	3,917,993	:		\$ 9,702	
Total all vehicles	156,951	:4,800,174:	2,190	:391,240:	5,191,414	:		\$12,459	

Total Annual Income..... \$12,459

	(Time Element Savings cont'd)			
	Local Traffic		Diverted Traffic @ 91.6%	
	New	Old	New	Old
<u>Trucks, Light</u>				
Average speed (miles per hour)..<	33.1	29.0		
Distance (miles).....	17.35	18.4		
Time (hours per trip).....	0.524	0.634		
Time savings per vehicle.....	0.110			
Value of savings (\$/vehicle-hour)	\$0.86			
Annual traffic volume.....	62,306			
Total.....	\$ 5,894		\$242	
<u>Trucks, Medium</u>				
Average speed (miles per hour)..<	29.1	25.0		
Distance (miles).....	17.35	18.4		
Time (hours per trip).....	0.596	0.736		
Time savings per vehicle.....	0.140			
Value of savings (\$/vehicle-hour)	\$1.17			
Annual traffic volume.....	6,278			
Total.....	\$ 1,028		\$90	
<u>Trucks, Heavy</u>				
Average speed (miles per hour)..<	26.1	22.0		
Distance (miles).....	17.35	18.4		
Time (hours per trip).....	0.665	0.836		
Time savings per vehicle.....	0.171			
Value of savings (\$/vehicle-hour)	\$1.47			
Annual traffic volume.....	11,461			
Total.....	\$ 2,881		\$315	
Total.....each category.....	\$ 14,140		\$2,306	
TOTAL ANNUAL TIME ELEMENT SAVINGS.....			\$ 16,446	

e. Mileage Element Savings

As per tabulation which follows:

HIGHWAY PROJECT ANALYSIS

Location of project		MONTANA		Mileage Element Savings	
Description of project		EKALAKA-US 212		County CARTER	
Highway number		FAS No. 323		Highway system FA SECONDARY	
Length 76.0 miles		Date of Analysis		APRIL 1946	
				Local Traffic	
				Diverted Traffic	
				@ 91.6%	
Distance		New		Old	
Length (miles).....		17.35		18.4	
Distance saving (miles).....		1.05			
Average annual traffic (tons).....		521,758			
Annual traffic saving (ton-mi.)...		547,846			
Cost (\$/ton-mile).....		\$0.0178			
Total.....		\$ 9,752		\$ 6,329	
Surface					
Roadway surface type.....		0.183		0.244	
Saving coefficient.....		1.061			
Aver. annual traffic (ton-mi.)....		9,600,347			
Saving (\$/ton-mile).....		\$0.0011			
Total.....		\$ 10,560		- \$214	

<u>Alignment</u>	(Mileage Element Savings cont'd)			
	New	Old	New	Old
Curvature rating.....	6.0	1.6		
Points improvement.....	4.4			
Saving (point-ton-miles).....	42,241,526			
Saving (\$/point-ton-mile).....	\$0.0001			
Total.....	\$ 4,224		\$64	
Total...each category.....	\$ 24,536		\$6,179	
TOTAL ANNUAL MILEAGE ELEMENT SAVINGS.....			\$ 30,715	

f. Traffic Benefits

As per tabulation which follows:

HIGHWAY PROJECT ANALYSIS

Location of project	MONTANA	County	CARTER
Description of project	EKALAKA-US 212		
Highway number	FAS No. 323	Highway system	FA SECONDARY
Length	76.0 miles	Date of analysis	APRIL 1946

Mileage Element Factors

Item		Fuel Function	Non-fuel Function
Distance savings	\$16,081 38%	\$ 6,111	\$ 9,970
Roadway surface savings	10,346 49.5%	5,121	5,225
Alignment savings	4,288 50%	2,144	2,144
Total Mileage Savings	\$30,715	\$ 13,376	\$ 17,339

Time Element Factors

Type of Traffic	Annual Value of Time Savings
Passenger cars	\$ 5,996
Trucks, light	6,136
Trucks, Medium	1,118
Trucks, heavy	3,196
Total Time Savings	\$ 16,446

Recapitulation of Annual Benefits

Total Fuel Function Benefits	\$ 13,376
Non-fuel Function (Mileage element factors	\$ 17,339
Benefits (Time element factors	\$ 16,446
Total Non-fuel Function Benefits	\$ 33,785
TOTAL ANNUAL BENEFITS	\$ 47,161

g. Derivation of Quotients
As per tabulation which follows:

HIGHWAY PROJECT ANALYSIS

Location of project	MONTANA	County	CARTER
Description of Project	EKALAKA-US 212		
Highway number	FAS No. 323	Highway system	FA SECONDARY
Length	76.0 Miles	Date of analysis	April 1946

$$\begin{aligned}
 I_{ar} &= \$ 12,459 & K_1 &= 1.00 \\
 C_a &= \$ 65,890 & K_2 &= 2,331/13,376 = 0.175 \\
 B_n &= \$ 33,785 & K_3 &= 0.05/0.20 = 0.25 \\
 B_f &= \$ 13,376 & K_2 K_3 &= 0.175 \times 0.25 = 0.045 \\
 K_1 C_a &= \$ 65,890 & 1-K_2 K_3 &= 1.00 - 0.045 = 0.955 \\
 Q_s = I_{ar}/K_1 C_a &= 12,459/65,890 = 0.19 \\
 Q_{Bn} = B_n/K_1 C_a &= 33,785/65,890 = 0.51 \\
 Q_{Bf} = B_f/K_1 C_a &= 13,376/65,890 = 0.205 \\
 Q'_s = Q_s - K_2 K_3 Q_{Bf} &= 0.19 - 0.045 \times 0.205 = 0.19 - 0.01 = 0.18 \\
 Q_c = 0.707 (Q_s / Q_{Bn} / Q_{Bf} (1-K_2 K_3)) &= 0.707 (0.19 / 0.51 / 0.205 \times 0.955) \\
 &= 0.707 (0.19 / 0.51 / 0.195) \\
 &= 0.707 \times 0.895 \\
 &= 0.63
 \end{aligned}$$

6. EKALAKA-ALZADA: Oiled Surface, 26.5 miles; Gravel Surface, 56.5 miles; total distance, 83.0 miles.

a. Annual Cost Calculations

New construction costs will be identical and equivalent to those set forth on tabulation, Analysis D, sub-section 5, a. Supplementing this cost we must consider the effective cost of the construction of the primary highway extending northwesterly from Alzada which comprises a part of the routing, on the basis of Ekalaka-Alzada traffic road use. It has been estimated that \$19,000 represents a fair allocation of these costs - the total construction cost would then be \$928,370 (\$909,370 / \$19,000).

These data are extended on the tabulation which follows to show the annual capital cost for construction- to this total there has been added an estimated annual maintenance charge to arrive at the total annual capital cost.

ANNUAL COST CALCULATIONS

Location of project MONTANA County CARTER
Description of project EKALAKA-ALZADA
Highway number FAS No. 323, 76.0 miles Highway system FA SECONDARY
: FA No. 23, 7.0 miles Highway system FA PRIMARY
Length 83.0 miles Date of analysis APRIL 1946

CAPITAL COSTS

Item	Net Cost	Interest Rate	Amort. Period	Annual Capital Cost
Rights of way, easements, etc.	\$ 32,350	2 1/2%	20 yrs.	\$ 2,073
Clearing, grading, etc.	304,000	"	"	19,486
Pavements and surfacing:				
Type <u>Gravel Base & Surface</u>	266,000	"	"	17,051
Type <u>Oil Surface</u>	39,000	"	"	2,500
Structures:				
Type <u>Major, 1 Steel</u>	15,000	"	"	962
Type <u>Major, 7 Timber</u>	42,000	"	"	2,692
Type <u>Minor</u>	60,800	"	"	3,897
Engineering and Administration....	67,550	"	"	4,330
/ 10% for contingencies.....	82,670	"	"	5,299
Unamortized cost old const.....	19,000	"	"	1,218
1. Total annual capital cost.....				\$ 59,508
2. Total annual maintenance cost	7.0 Miles @ \$48.00			
:	76.0 Miles @ \$100.00			\$ 7,936
TOTAL ANNUAL COSTS (1 + 2)				\$ 67,444

b. Average Daily Traffic, 1960

(1) Local Traffic

Average traffic and travel-distance data are as shown on page 145.

(2) Diverted Traffic

Six vehicles per day per mile effective over the total length of the routing.

c. Annual Revenues

As per tabulation shown on page 146.

d. Time Element Savings

As per tabulation which follows:

HIGHWAY PROJECT ANALYSIS

Time Element Savings

Location of project MONTANA County CARTER
Description of project EKALAKA-ALZADA
Highway number FAS No. 323 & FA No. 23 Highway system FA SECONDARY & FA PRIMARY
Length 83.0 miles Date of analysis APRIL 1946

LOCAL TRAFFIC AND TRAVEL-DISTANCE DATA AS OF COMPLETION OF
THE EKALAKA-ALZADA ROUTING VIA CHALK BUTTES, RIDGEMAY, HAY
CREEK (PINELE ROAD) AND A POINT ON US 212 SEVEN
MILES NORTHWEST OF ALZADA

:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:</
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HIGHWAY PROJECT ANALYSIS

Traffic Income

Location of project Montana Highway FAS No. 323 FA No. 23
 Description of project Ekalaka - Alzada Length 83.0 miles Date of analysis April 1946
 Highway System FA Secondary FA Primary

Traffic Type	Average Annual Traffic			Average Annual: Unit Net: Total Annual		
	Local Traffic		Diverted Traffic	Road Use During Revenues		Net Revenue
	Vehicles	Ton	Vehicles	Ton	Life of Project Per Ton Mi.	
	Miles		Miles			
Passenger Cars - Montana	74,453	1,144,710	1,588	197,623	1,342,333	\$0.002188
Passenger Cars - Foreign	3,168	48,718	273	33,947	82,665	0.001799
Total passenger cars	77,621	1,193,428	1,861	231,570	1,424,998	
Trucks, light	62,886	2,107,769	176	47,725	2,155,494	0.003248
Trucks, medium	6,336	146,849	43	24,568	471,417	0.002382
Trucks, heavy	3,499	399,924	6	5,561	405,485	0.001619
Trucks, semi-trailer	3,942	596,437	43	52,622	649,059	0.001543
Trucks, full-trailer	1,916	149,452	17	32,204	481,656	0.001396
Busses	2,210	203,903	144	32,868	236,771	0.001873
Total trucks & busses	80,789	4,204,334	329	195,548	4,399,882	
Total all vehicles	158,410	5,397,762	2,190	427,118	5,824,880	

Total Annual Income..... \$13,982

(Time Element Savings cont'd)				
	Local Traffic		Diverted Traffic	
			@ 100%	
Annual Traffic Volume	New	Old	New	Old
Private Passenger cars (per year)	77,621			
Trucks, light (per year).....	62,886			
Trucks, medium (per year).....	6,336			
Trucks, heavy (per year).....	11,567			
Totals.....	158,410			
<u>Private Passenger Cars</u>				
Average speed (miles per hour)...	36.1	32.0		
Distance (miles).....	17.15	18.25		
Time (hours per trip).....	0.475	0.570		
Time savings per vehicle.....	0.095			
Value of savings (\$/vehicle-hour)	\$0.60			
Annual traffic volume.....	77,621			
Total.....	\$ 4,424		\$ 1,811	
<u>Trucks, Light</u>				
Average speed (miles per hour)...	33.1	29.0		
Distance (miles).....	17.15	18.25		
Time (hours per trip).....	0.518	0.629		
Time savings per vehicle.....	0.111			
Value of savings (\$/vehicle-hour)	\$0.86			
Annual traffic volume.....	62,886			
Total.....	\$ 6,003		\$264	
<u>Trucks, Medium</u>				
Average speed (miles per hour)...	29.1	25.0		
Distance (miles).....	17.15	18.25		
Time (hours per trip).....	0.589	0.730		
Time savings per vehicle.....	0.141			
Value of savings (\$/vehicle-hour)	\$1.17			
Annual traffic volume.....	6,336			
Total.....	\$ 1,045		\$98	
<u>Trucks, Heavy</u>				
Average speed (miles per hour)...	26.1	22.0		
Distance (miles).....	17.15	18.25		
Time (hours per trip).....	0.657	0.830		
Time savings per vehicle.....	0.173			
Value of savings (\$/vehicle-hour)	\$1.47			
Annual traffic volume.....	11,567			
Total.....	\$ 2,942		\$344	
Total...each category.....	\$ 14,414		\$2,517	
TOTAL ANNUAL TIME ELEMENT SAVINGS.....			\$ 16,931	

HIGHWAY PROJECT ANALYSIS

Location of project	MONTANA	County	CARTER
Description of project	EKALAKA-ALAZADA		
Highway number	FAS No. 323 & FA No. 23	Highway system	FA SECONDARY & FA PRIMARY
Length	83.0 miles	Date of analysis	APRIL 1946

Distance	Local Traffic		Diverted Traffic @ 100%	
	New	Old	New	Old
Length (miles).....	17.15	18.25		
Distance saving (miles).....	1.1			
Average annual traffic (tons)....	526,611			
Annual traffic saving (ton-mi.)..	579,272			
Cost (\$/ton-mile).....	\$0.0178			
Total.....	\$ 10,311		\$6,909	
Surface				
Roadway surface type.....	0.18	0.24		
Saving coefficient.....	0.06			
Aver. annual traffic (ton-mi.)...	9,610,651			
Saving (\$/ton-mile).....	\$0.00105			
Total.....	\$10,091		- \$234	
Alignment				
Curvature rating.....	6.0	1.6		
Points improvement.....	4.4			
Saving (point-ton-miles).....	42,286,864			
Saving (\$/point-ton-mile).....	\$0.0001			
Total.....	\$ 4,229		\$70	
Total...each category.....	\$ 24,631		\$6,745	
TOTAL ANNUAL MILEAGE ELEMENT SAVINGS.....			\$ 31,376	

f. Traffic Benefits

As per tabulation which follows:

HIGHWAY PROJECT ANALYSIS

		Traffic Benefits	
Location of project	MONTANA	County	CARTER
Description of project	EKALAKA-ALZADA		
Highway number	FAS No. 323 & FA No. 23	Highway system	FA SECONDARY & FA PRIMARY
Length	83.0 miles	Date of analysis	APRIL 1946

Mileage Element Factors

Item			Fuel Function	Non-fuel Function
Distance savings	\$17,220	38%	\$ 6,544	\$ 10,676
Roadway surface savings	9,857	49.5%	4,879	4,978
Alignment savings	4,299	50%	2,150	2,149
Total Mileage Savings	\$31,376		\$ 13,573	\$ 17,803

Time Element Factors

Type of Traffic	Annual Value of Time Savings
Passenger cars	\$ 6,235
Trucks, light	6,267
Trucks, medium	1,143
Trucks, heavy	3,286
Total Time Savings	\$ 16,931

Recapitulation of Annual Benefits

Total Fuel Function Benefits	<u>\$13,573</u>
Non-fuel Function (Mileage element factors \$ 17,803 benefits (Time element factors \$ 16,931	<u>\$34,734</u>
Total Non-fuel Function Benefits	<u>\$48,307</u>
TOTAL ANNUAL BENEFITS	<u>\$48,307</u>

g. Derivation of Quotients
As per tabulation which follows:

HIGHWAY PROJECT ANALYSIS

Location of project MONTANA County CARTER
Description of project EKALAKA-ALZADA
Highway number FAS No. 323 & FA No. 23 Highway system FA SECONDARY & FA PRIMARY
Length 83.0 Miles Date of analysis APRIL 1946

$$\begin{aligned}
 I_{ar} &= \$ 13,982 & K_1 &= 1.00 \\
 C_a &= \$ 67,444 & K_2 &= 2,545/13,573 = 0.185 \\
 B_n &= \$ 34,734 & K_3 &= 0.05/0.20 = 0.25 \\
 B_f &= \$ 13,573 & K_2K_3 &= 0.185 \times 0.25 = 0.045 \\
 K_1C_a &= \$ 67,444 & 1-K_2K_3 &= 1.00 - 0.045 = 0.955 \\
 Q_s &= I_{ar}/K_1C_a = 13,982/67,444 = 0.205 \\
 Q_{Bn} &= B_n/K_1C_a = 34,734/67,444 = 0.515 \\
 Q_{Bf} &= B_f/K_1C_a = 13,573/67,444 = 0.20 \\
 Q'_s &= Q_s - K_2K_3Q_{Bf} = 0.205 - 0.045 \times 0.20 = 0.205 - 0.01 = 0.195 \\
 Q_c &= 0.707 (Q_s/Q_{Bn}/Q_{Bf} (1-K_2K_3)) = 0.707 (0.205 / 0.515 / 0.20 \times 0.955) \\
 &= 0.707 (0.205 / 0.515 / 0.19) \\
 &= 0.707 \times 0.91 \\
 &= 0.64
 \end{aligned}$$

Note composite solvency quotient to be 0.07 in excess of that quotient developed in Analysis A, sub-section 6, g but 0.12 lower than the quotient developed in Analysis C sub-section 5, g.

E. EKALAKA-ALZADA; Secondary, 80.0 miles, via Chalk Buttes, Ridgeway, and Albion. This analysis proposes study of a routing which has been previously analyzed in part in Analysis D.

1-3 EKALAKA-PINIELE ROAD: Oiled Surface, 19.5 miles ; Gravel Surface, 22.5 miles; total distance, 42.0 miles. This series of analyses has been condensed to cover three intervals; Ekalaka to the Broadus Road turn-off, Ekalaka to Ridgeway and Ekalaka to the Piniele Road turn-off. It is obvious that the benefits in traffic road use will conform very closely to those values computed and set forth in Analysis D, sub-sections 1-3.

a. Annual Capital Costs

Annual capital costs will be equal to those computed in Analysis D, sub-section 3, a.

b. Average Daily Traffic, 1960

(1) Local Traffic

Average daily traffic and travel-distance data are as shown on page 151.

(2) Diverted Traffic

This element of traffic, 6 vehicles, per day per mile, will be effective over 52.5% of the total length of the routing.

c. Annual Revenues

As per tabulation shown on page 152.

d. Time Element Savings

As per tabulation which follows:

HIGHWAY PROJECT ANALYSIS

Time Element Savings

Location of project	MONTANA		County	CARTER		
Description of project	EKALAKA-PINIELE ROAD					
Highway number	FAS No. 323		Highway system	FA SECONDARY		
Length	42.0 miles		Date of analysis	APRIL 1946		
			Local Traffic	Diverted Traffic		
				@ 52.5%		
	<u>Annual Traffic Volume</u>		New	Old	New	Old
Private Passenger cars (per year)			63,327		1,861	
Trucks, light (per year).....			51,283		176	
Trucks, medium (per year).....			5,147		43	
Trucks, heavy (per year).....			9,453		110	
Totals.....			129,210		2,190	
	<u>Private Passenger Cars</u>					
Average speed (miles per hour)...			34.4	30.4	41.5	41.5
Distance (miles).....			17.85	18.35	155.0	227.0
Time (hours per trip).....			0.519	0.604	3.735	5.469
Time savings per vehicle.....			0.085		1.734	
Value of savings (\$/vehicle-hour)			\$0.60		\$0.60	
Annual traffic volume.....			63,327		1,861	
Value of time savings.....					\$1,936	
Totals.....			\$ 3,230		\$1,016,	52.5%
	<u>Trucks, Light</u>					
Average speed (miles per hour)...			31.4	27.4	38.5	38.5
Distance (miles).....			17.85	18.35	155.0	227.0
Time (hours per trip).....			0.568	0.670	4.026	5.896

LOCAL TRAFFIC AND TRAVEL-DISTANCE DATA AS OF COMPLETION
OF THE EKALAKA-PINELE ROAD SECTION OF THE EKALAKA-
CHALK BUTTES-RIDGEWAY-ALBION-ALZADA ROUTING

		EXISTING FACILITIES (Miles)				NEW FACILITIES (Miles)						
		PTW	APPROACH	TOTAL TRAVEL-DISTANCE	NEW	APPROACH	TOTAL TRAVEL-DISTANCE					
CLASSIFICATION	ADT	GRAVEL:UNIMP:	OIL:UNIMP:	GRAVEL:UNIMP:TOTAL:	OIL:GRAVEL:	OIL:UNIMP:	TOTAL GRAVEL:UNIMP:TOTAL:					
Existing Traffic	222	10.35	12.85	23.2	4.8	1.95	15.6	4.8	1.95	15.6	22.35	
Diverted Traffic	132	1.65	6.05	0.5	1.95	8.0	10.15	3.4	3.35	0.5	3.05	10.3
Local Traffic	354	0.6	8.75	0.2	8.8	0.6	17.55	18.35	4.3	2.45	10.9	17.85

HIGHWAY PROJECT ANALYSIS

Traffic Income

Location of project Montana Highway FAS No. 323 Description of project Ekalaka - Pinele Road Highway System FA Secondary Length 42.0 Miles Date of analysis April 1946 County Carter

Traffic Type	Average Annual Traffic			Average Annual: Unit Net :Total Annual		
	Local Traffic		Diverted Traffic	Road Use During: Revenues :Net Revenue		
	Vehicles	Ton	Vehicles	Ton	Life of Project Per Ton Mi:	
	Miles	Miles	Miles	Miles	Ton Mile	
Passenger Cars - Montana	60,376	614,952	1,588	100,002	714,954	\$0.002188
Passenger Cars - Foreign	2,591	26,327	273	17,178	43,415	0.001799
Total passenger cars	63,237	641,189	1,861	117,180	758,369	\$1.642
Trucks, light	51,283	1,131,941	176	24,150	1,156,091	0.003248
Trucks, medium	5,147	239,024	43	12,432	251,456	0.002382
Trucks, heavy	2,847	214,272	6	2,814	217,086	0.001619
Trucks, semi-trailer	3,248	323,595	43	26,628	350,223	0.001543
Trucks, full-trailer	1,533	236,857	17	16,296	253,153	0.001396
Busses	1,825	110,869	44	16,632	127,501	0.001873
Total trucks & busses	65,883	2,256,558	329	98,952	2,355,510	\$5.837
Total all vehicles	129,210	2,897,747	2,190	216,132	3,113,879	\$7.479

Total Annual Income..... \$7.479

	(Time Element Savings cont'd)			
	Local Traffic		Diverted Traffic @ 52.5%	
	New	Old	New	Old
<u>Trucks, Light(cont'd)</u>				
Time savings per vehicle.....	0.102		1.870	
Value of savings (\$/vehicle-hour)	\$0.86		\$0.86	
Annual traffic volume.....	51,283		176	
Value of time savings.....			\$283	
Total.....	\$ 4,499		\$149, 52.5%	
<u>Trucks, Medium</u>				
Average speed (miles per hour)....	27.4	23.4	34.5	34.5
Distance (miles).....	17.85	18.35	155.0	227.0
Time (hours per trip).....	0.651	0.784	4.493	6.580
Time savings per vehicle.....	0.133		2.087	
Value of savings (\$/vehicle-hour).	\$1.17		\$1.17	
Annual traffic volume.....	5,147		43	
Value of time savings.....			\$105	
Total.....	\$ 801		\$55, 52.5%	
<u>Trucks, Heavy</u>				
Average speed (miles per hour)....	24.4	20.4	31.5	31.5
Distance (miles).....	17.85	18.35	155.0	227.0
Time (hours per trip).....	0.732	0.900	4.921	7.206
Time savings per vehicle.....	0.168		2.285	
Value of savings (\$/vehicle-hour).	\$1.47		\$1.47	
Annual traffic volume.....	9,453		110	
Value of time savings.....			\$369	
Total.....	\$ 2,335		\$194, 52.5%	
Total...each category.....	\$ 10,865		\$1,414	
TOTAL ANNUAL TIME ELEMENT SAVINGS.....			\$ 12,279-	

e. Mileage Element Savings
As per tabulation which follows:

HIGHWAY PROJECT ANALYSIS

Mileage Element Savings

Location of project	MONTANA		County		CARTER	
Description of project	EKALAKA--PINIELE ROAD					
Highway number	FAS No. 323		Highway system		FA SECONDARY	
Length	42.0 miles		Date of Analysis		APRIL 1946	
			Local Traffic		Diverted Traffic	
			New	Old	New	Old
Distance						
Length (miles).....			17.85	18.35	155.0	227.0
Distance saving (miles).....			0.5		72.0	
Average annual traffic (tons).....			429,296		5,146	
Annual traffic saving (ton-mi.)....			214,648		370,512	
Cost (\$/ton-mile).....			\$0.0178		\$0.0196	
Annual saving.....					\$7,262	
Total.....			\$ 3,821		\$3,812	52.5%
Surface						
Roadway surface type.....			0.205	0.274	0.077	0.077
Saving coefficient.....			0.069		No saving	
Aver. annual traffic (ton-mi.)....			7,877,582			
Saving (\$/ton-mile).....			\$0.0012			
Total.....			\$ 9,453			

Alignment	Mileage Element Savings cont'd)			
	Local Traffic		Diverted Traffic	
	New	Old	New	Old
Curvature rating.....	3.9	0.4	10.0	9.4
Points improvement.....	3.5		0.6	
Saving (point-ton-miles).....	27,571,537		700,885	
Saving (\$/point-ton-mile).....	\$0.0001		\$0.0001	
Annual saving.....			\$70	
Total.....	\$ 2,757		\$37, 52.5%	
Total....each category.....	\$ 16,031		3,849	
TOTAL ANNUAL MILEAGE ELEMENT SAVINGS.....			\$ 19,880	

f. Traffic Benefits

As per tabulation which follows:

HIGHWAY PROJECT ANALYSIS

Traffic Benefits

Location of project MONTANA County CARTER
Description of project EKALAKA-PINIELE ROAD
Highway number FAS No. 323 Highway system FA SECONDARY
Length 42.0 miles Date of analysis April 1946

Mileage Element Factors

Item		Fuel Function	Non-fuel Function
Distance savings	\$7,633 38%	\$ 2,900	\$ 4,733
Roadway surface savings	9,453 44%	4,159	5,294
Alignment savings	2,794 50%	1,397	1,397
Total Mileage Savings	\$ 19,880	\$ 8,456	\$ 11,424

Time Element Factors

Type of Traffic	Annual Value of Time Savings
Passenger cars	\$ 4,246
Trucks, light	4,648
Trucks, medium	856
Trucks, heavy	2,429
Total Time Savings	\$ 12,179

Recapitulation of Annual Benefits

Total Fuel Function Benefits	\$ 8,456
Non-fuel function (Mileage element factors benefits (Time element factors	\$ 11,424 \$ 12,179
Total Non-fuel Function Benefits	\$23,603
TOTAL ANNUAL BENEFITS	\$32,059

- g. Derivation of Quotients
As per tabulation which follows:

HIGHWAY PROJECT ANALYSIS

Location of project	MONTANA	County	CARTER
Description of project	EKALAKA-PINIELE ROAD		
Highway number	FAS No. 323	Highway system	FA SECONDARY
Length	42.0 miles	Date of analysis	APRIL 1946

$$I_{ar} = \$ 7,479 \quad K_1 = 1.00$$

$$C_a = \$ 36,385 \quad K_2 = 1,467/7,479 = 0.195$$

$$B_n = \$ 23,603 \quad K_3 = 0.05/0.20 = 0.25$$

$$B_f = \$ 8,456 \quad K_2 K_3 = 0.05$$

$$K_1 C_a = \$ 36,385 \quad 1 - K_2 K_3 = 1.00 - 0.05 = 0.95$$

$$Q_s = I_{ar}/K_1 C_a = 7,479/36,385 = 0.205$$

$$Q_{Bn} = B_n/K_1 C_a = 23,603/36,385 = 0.65$$

$$Q_{Bf} = B_f/K_1 C_a = 8,456/36,385 = 0.23$$

$$Q'_s = Q_s - K_2 K_3 Q_{Bf} = 0.205 - 0.05 \times 0.23 = 0.205 - 0.01 = 0.195$$

$$Q_c = 0.707 (Q_s/Q_{Bn}/Q_{Bf}(1 - K_2 K_3)) = 0.707 (0.205 / 0.65 / 0.23 \times 0.95)$$

$$= 0.707 (0.205 / 0.65 / 0.22)$$

$$= 0.707 \times 1.075$$

$$= 0.76$$

Note that the solvency quotient listed hereabove is slightly in excess of that determined in Analysis D, sub-section 3, g.

4. EKALAKA-ALBION: Oiled Surface, 19.5 miles, Gravel Surface, 46.0 miles; total length, 65.5 miles.

a. Annual Cost Calculations

Details of construction costs are as follows:

Grading, 65.5 miles @ \$4,000 per mile..... \$262,000

Gravel Base and Surface, 65.5 miles @ \$3,500 per mile..... \$229,250

Major Drainage Structures, bridges

2 Steel, 250 feet @ \$150 per lineal foot..... \$37,500

3 Timber, 180 feet @ \$100 per lineal foot..... \$18,000

Minor Drainage Structures, 65.5 miles @ \$800 per mile..... \$52,400

Oiled Surface, 19.5 miles @ \$2,000 per mile..... \$39,000

Rights-of-Way

19.5 miles @ \$500 per mile..... \$9,750

46 miles @ \$400 per mile..... \$18,400

Engineering and Administration

Grade, gravel, and oil 19.5 miles @ \$1,000 per mile..... \$19,500

Grade and gravel 46 miles @ \$800 per mile..... \$36,800

Bridges, 5% of \$55,500..... \$2,775

Sub-total.....\$725,375

✓ 10% for contingencies..... \$72,538

Total construction costs, 65.5 miles.....\$797,913

In the tabulation which follows these data are combined with maintenance costs to arrive at an annual capital cost.

ANNUAL COST CALCULATIONS

Location of project	MONTANA	County	CARTER
Description of project	EKALAKA-ALBION		
Highway number	FAS No. 323	Highway system	FA SECONDARY
Length	65.5 miles	Date of Analysis	APRIL 1946

Item	CAPITAL COSTS			Annual Capital Cost
	Net Cost	Interest Rate	Amort. Period	
Rights of way, easements, etc.	\$ 28,150	2 1/2%	20 yrs.	\$ 1,804
Clearing, grading, etc.	262,000	"	"	16,794
Pavements and surfacing:				
Type Gravel, Base & Surface	229,250	"	"	14,695
Type Oil Surface	39,000	"	"	2,500
Structures:				
Type Major, 2 Steel	37,500	"	"	2,404
Type Major, 3 Timber	18,000	"	"	1,154
Type Minor	52,400	"	"	3,359
Engineering & Administration.....	59,075	"	"	3,787
✓ 10% for contingencies.....	72,538	"	"	4,650

1. Total annual capital cost..... \$ 51,147

2. Total annual maintenance cost 65.5 mi. @ \$100.00 \$ 6,550

TOTAL ANNUAL COSTS (1 + 2) \$ 57,697

b. Average Daily Traffic, 1960

(1) Local Traffic

Average daily traffic and travel-distance data are as shown on page 157.

LOCAL TRAFFIC AND TRAVEL-DISTANCE DATA AS OF COMPLETION
OF THE EKALAKA-ALBION SECTION OF THE EKALAKA-CHALK BUTTES
-RIDGEMAY-ALBION ROUTING

		EXISTING FACILITIES (Miles)			NEW FACILITIES (Miles)		
		PTW	APPROACH :	TOTAL TRAVEL-DISTANCE :	NEW	APPROACH :	TOTAL TRAVEL-DISTANCE :
TRAFFIC CLASSIFICATION:	ADT :	GRAVEL:UNIMP :	OIL : UNIMP :	TOTAL : GRAVEL:UNIMP :	OIL :	GRAVEL :	TOTAL : OIL : GRAVEL:UNIMP :
Existing Traffic	248	: 11.1 :	: 12.95 :	: 24.05 :	4.3 :	5.2 :	: 13.75 : 23.25 :
Diverted Traffic	102	: 2.25 :	: 8.65 :	: 0.6 : 2.65 :	0.6 :	4.95 :	: 4.15 : 5.15 : 4.95 :
Local Traffic	350	: 0.65 :	: 10.4 :	: 0.2 : 9.95 :	0.2 :	10.95 :	: 4.55 : 5.15 : 10.95 :

(2) Diverted Traffic

This element of traffic will be effective over 81.9% of the total length of the routing.

c. Annual Revenues

As per tabulation shown on page 159.

d. Time Element Savings

As per tabulation which follows:

HIGHWAY PROJECT ANALYSIS

Time Element Savings

Location of project MONTANA County CARTER
Description of project EKALAKA-ALBION
Highway number FAS No. 323 Highway system FA SECONDARY
Length 65.5 miles Date of analysis APRIL 1946

	Local Traffic		Diverted Traffic @ 81.9%	
Annual Traffic Volume	New	Old	New	Old
Private Passenger cars (per year)	62,598			
Trucks, light (per year).....	50,735			
Trucks, medium (per year).....	5,110			
Trucks, heavy (per year).....	9,308			
Totals.....	127,751			
Private Passenger Cars				
Average speed (miles per hour)...	34.9	30.4		
Distance (miles).....	20.65	21.2		
Time (hours per trip).....	0.592	0.697		
Time savings per vehicle.....	0.105			
Value of savings (\$/vehicle-hour)	\$0.60			
Annual traffic volume.....	62,598			
Total.....	\$ 3,944		\$1,586	
Trucks, Light				
Average speed (miles per hour)...	31.9	27.4		
Distance (miles).....	20.65	21.2		
Time (hours per trip).....	0.647	0.774		
Time savings per vehicle.....	0.127			
Value of savings (\$/vehicle-hour)	\$0.86			
Annual traffic volume.....	50,735			
Total.....	\$ 5,541		\$232	
Trucks, Medium				
Average speed (miles per hour)...	27.9	23.4		
Distance (miles).....	20.65	21.2		
Time (hours per trip).....	0.740	0.906		
Time savings per vehicle.....	0.166			
Value of savings (\$/vehicle-hour)	\$1.17			
Annual traffic volume.....	5,110			
Total.....	\$ 992		\$86	
Trucks, Heavy				
Average speed (miles per hour)...	24.9	20.4		
Distance (miles).....	20.65	21.2		
Time (hours per trip).....	0.829	1.039		
Time savings per vehicle.....	0.210			
Value of savings (\$/vehicle-hour)	\$1.47			
Annual traffic volume.....	9,308			

HIGHWAY PROJECT ANALYSIS

Traffic Income

Location of project Montana Highway FAS No. 323 Description of project Ekalaka - Albion Highway System FA Secondary Length 65.5 County Carter Date of analysis April 1946

Traffic Type	Average Annual Traffic				Average Annual			Unit Net		Total Annual
	Local Traffic		Diverted Traffic		Road Use During			Revenues		Net Revenue
	Vehicles	Ton	Vehicles	Ton	Life of Project			Per Ton Mi.		
		Miles		Miles	Ton Mi.					
Passenger Cars - Montana	60,043	855,608	1,588	156,003	1,011,611	\$0.002188	\$2,213			
Passenger Cars - Foreign	2,555	36,414	273	26,798	63,212	0.001799	114			
Total passenger cars	62,598	892,022	1,861	182,801	1,074,823		\$2,327			
Trucks, light	50,735	1,576,078	176	37,674	1,613,752	0.003248	5,241			
Trucks, medium	5,110	333,992	43	19,394	353,386	0.002382	842			
Trucks, heavy	2,810	297,654	6	4,390	302,044	0.001619	489			
Trucks, semi-trailer	3,176	445,341	43	41,540	486,881	0.001543	751			
Trucks, full-trailer	1,533	333,355	17	25,422	358,777	0.001396	501			
Busses	1,789	152,959	44	25,946	178,905	0.001873	335			
Total trucks & busses	65,153	3,139,379	329	154,366	3,293,745		\$8,159			
Total all vehicles	127,751	4,031,401	2,190	337,167	4,368,568		\$10,486			

Total annual income..... \$10,486

(Time Element Savings cont'd)
 Local Traffic Diverted Traffic
 @ 81.9%

	New	Old	New	Old
Total.....	\$ 2,873		\$302	
Total...each category.....	<u>13,350</u>		<u>\$2,206</u>	

TOTAL ANNUAL TIME ELEMENT SAVINGS.....\$ 15,556

e. Mileage Element Savings
 As per tabulation which follows:

HIGHWAY PROJECT ANALYSIS

Mileage Element Savings

Location of project	MONTANA	County	CARTER
Description of Project	EKALAKA-ALBION		
Highway number	FAS No. 323	Highway system	FA SECONDARY
Length	65.5 miles	Date of analysis	APRIL 1946

	Local Traffic		Diverted Traffic @ 81.9%	
	New	Old	New	Old
Distance				
Length (miles).....	20.65	21.2		
Distance saving (miles).....	0.55			
Average annual traffic (tons).....	424,358			
Annual traffic saving (ton-mi.)...	233,397			
Cost (\$/ton-mile).....	\$0.00178			
Total.....	<u>\$ 4,154</u>		<u>\$5,948</u>	

Surface				
Roadway surface type.....	0.202	0.275		
Saving coefficient.....	0.073		No saving.	
Aver. annual traffic (ton-mi.)....	8,996,390			
Saving (\$/ton-mile).....	\$0.0013			
Total.....	<u>\$ 11,695</u>			

Alignment				
Curvature rating.....	4.7	0.4		
Points improvement.....	4.3			
Saving (point-ton-miles).....	38,684,477			
Saving (\$/point-ton-mile).....	\$0.0001			
Total.....	<u>\$ 3,868</u>		<u>\$57</u>	
Total....each category.....	<u>\$19,717</u>		<u>\$6,005</u>	

TOTAL ANNUAL MILEAGE ELEMENT SAVINGS.....\$ 25,722

f. Traffic Benefits
 As per tabulation which follows:

HIGHWAY PROJECT ANALYSIS

Traffic Benefits

Location of project	MONTANA	County	CARTER
Description of project	EKALAKA-ALBION		
Highway number	FAS No. 323	Highway system	FA SECONDARY
Length	65.5 miles	Date of Analysis	APRIL 1946

(Traffic Benefits cont'd)

Mileage Element Factors

Item			Fuel Function	Non-fuel Function
Distance savings	\$10,102	38%	\$ 3,839	\$ 6,263
Roadway surface savings	11,695	44.5%	5,204	6,491
Alignment savings	3,925	50%	1,963	1,962
Total Mileage Savings	\$25,722		\$ 11,006	\$ 14,716

Time Element Factors

Type of Traffic	Annual Value of Time Savings
Passenger cars	\$ 5,530
Trucks, light	5,773
Trucks, medium	1,078
Trucks, heavy	3,175
Total Time Savings	\$ 15,556

Recapitulation of Annual Benefits

Total Fuel Function Benefits	\$ 11,006
Non-fuel function benefits (Mileage element factors)	\$ 14,716
(Time element factors)	\$ 15,556
Total Non-fuel Function Benefits	\$ 30,272
TOTAL ANNUAL BENEFITS	\$ 41,278

g. Derivation of Quotients

As per tabulation which follows:

HIGHWAY PROJECT ANALYSIS

Location of project	MONTANA	County	CARTER
Description of project	EKALAKA-ALBION		
Highway number	FAS No. 323	Highway system	FA SECONDARY
Length	65.5 miles	Date of Analysis	APRIL 1946

$I_{ar} = \$$	10,486	$K_1 =$	1.00
$C_a = \$$	57,697	$K_2 =$	$2,289/11,006 = 0.21$
$B_n = \$$	30,272	$K_3 =$	$0.05/0.20 = 0.25$
$B_f = \$$	11,006	$K_2 K_3 =$	$0.21 \times 0.25 = 0.05$
$K_1 C_a = \$$	57,697	$1 - K_2 K_3 =$	$1.00 - 0.05 = 0.95$
$Q_s = I_{ar}/K_1 C_a =$	$10,486/57,697 = 0.18$		

(Derivation of Quotients cont'd)

$$Q_{Bn} = B_n / K_1 C_a = 30,272 / 57,697 = 0.525$$

$$Q_{Bf} = B_f / K_1 C_a = 11,006 / 57,697 = 0.19$$

$$Q'_s = Q_s - K_2 K_3 Q_{Bf} = 0.18 - 0.05 \times 0.19 = 0.18 - 0.01 = 0.17$$

$$Q_c = 0.707 (Q_s / Q_{Bn} / Q_{Bf} (1 - K_2 K_3)) = 0.707 (0.18 / 0.525 / 0.19 \times 0.95)$$

$$= 0.707 (0.18 / 0.525 / 0.18)$$

$$= 0.707 \times 0.885$$

$$= 0.625$$

Note that the composite solvency quotient, 0.625, is 0.105 less than the composite solvency quotient listed in Analysis C sub-section 4, g.

5. EKALAKA-ALZADA: Oiled Surface, 34 miles; Gravel Surface, 46 miles; total distance, 80.0 miles.

a. Annual Cost Calculations

Construction costs are summarized herebelow.

Grade 80.0 miles @ \$4,000 per mile.....	\$320,000
Gravel Base and Surface, 80.0 miles @ \$3,500 per mile.....	\$280,000
Major Drainage Structures, bridges	
2 Steel, 250 feet @ \$150 per lineal foot.....	\$37,500
6 Timber, 360 feet @ \$60 per lineal foot.....	\$36,000
Minor Drainage Structures, 80.0 miles @ \$800 per mile.....	\$64,000
Oiled Surface, 34.0 miles @ \$2,000 per mile.....	\$68,000
Rights-of-Way	
34.0 miles @ \$500 per mile.....	\$17,000
46.0 miles @ \$400 per mile.....	\$18,400
Engineering and Administration	
Grade, gravel, and oil 34.0 miles @ \$1,000 per mile.....	\$34,000
Grade and gravel 46.0 miles @ \$800 per mile.....	\$36,800
Bridges, 5% of \$73,500.....	\$3,675
Sub-total.....	\$915,375
+ 10% for contingencies.....	\$91,538

Total construction costs, 80.0 miles..... \$1,006,913

These data are combined with estimated annual maintenance costs in the tabulation which follows to arrive at the total annual capital cost.

ANNUAL COST CALCULATIONS

Location of project	MONTANA	County	CARTER
Description of project	EKALAKA-ALZADA		
Highway number	FAS No. 323	Highway system	FA SECONDARY
Length	80.0 miles	Date of analysis	APRIL 1946

Item	CAPITAL COSTS			Annual Capital Cost
	Net Cost	Interest Rate	Amort. Period	
Rights of way, easements, etc.	\$ 35,400	2 1/2%	20 yrs.	\$ 2,269
Clearing, grading, etc.	320,000	"	"	20,512
Pavements and surfacing:				
Type Gravel Base & Surface	280,000	"	"	17,948
Type Oil Surface	68,000	"	"	4,359
Structures:				
Type Major, 2 Steel	37,500	"	"	2,404
Type Major, 6 Timber	36,000	"	"	2,308
Type Minor	64,000	"	"	4,102
Engineering & Administration.....	74,475	"	"	4,774
10% for contingencies.....	91,538	"	"	5,867

1. Total annual capital cost.....\$ 64,543

2. Total annual maintenance cost 80.0 miles @ \$100.00 \$ 8,000

TOTAL ANNUAL COSTS (1 + 2) \$ 72,543

b. Average Daily Traffic, 1960

(1) Local Traffic

Average daily traffic and travel-distance data are as shown on page 164.

(2) Diverted Traffic

This element of traffic, 6 vehicles per day per mile, will be effective over the total length of the routing.

c. Annual Revenues

As per tabulation shown on page 165.

d. Time Element Savings

As per tabulation which follows:

HIGHWAY PROJECT ANALYSIS

Time Element Savings

Location of project	MONTANA	County	CARTER
Description of project	EKALAKA-ALZADA		
Highway number	FAS No. 323	Highway system	FA SECONDARY
Length	80.0 miles	Date of analysis	APRIL 1946

[illegible]

HIGHWAY PROJECT ANALYSIS

Traffic Income

Location of project Montana Highway System FA Secondary Description of project Ekalaka - Alzada Length 80.0 miles Date of analysis April 1946

Traffic Type	Average Annual Traffic				Average Annual: Unit Net				Total Annual : :Road Use During: Revenues : Net Revenue		
	Local Traffic		Diverted Traffic		:Life of Project:Per Ton Mi.:						
	Vehicles	Ton	Vehicles	Ton	:Ton Mi.:						
	: Vehicles :	: Miles :	: Vehicles :	: Miles :	:						
Passenger Cars - Montana	78,730	:1,115,998:	1,588	:190,450	:	:	:	:	1,306,478	:40.002188:	\$2,859
Passenger Cars - Foreign	3,358	:47,600:	273	:32,720	:	:	:	:	80,320	:0.001799:	144
Total passenger cars	82,088	:1,163,598:	1,861	:223,200	:	:	:	:	1,386,798	:	\$3,003
Trucks, light	66,503	:2,055,044:	176	:46,000	:	:	:	:	2,101,044	:0.003248:	\$6,824
Trucks, medium	6,716	:436,616:	43	:23,680	:	:	:	:	460,326	:0.002382:	1,096
Trucks, heavy	3,687	:388,490:	6	:5,360	:	:	:	:	393,850	:0.001619:	638
Trucks, semi-trailer	4,197	:585,409:	43	:50,720	:	:	:	:	636,129	:0.001543:	982
Trucks, full-trailer	2,008	:434,350:	17	:31,040	:	:	:	:	465,390	:0.001396:	650
Busses	2,336	:198,677:	14	:31,680	:	:	:	:	230,357	:0.001873:	431
Total trucks & busses	85,147	:4,098,616:	329	:188,480	:	:	:	:	4,281,096	:	\$10,621
Total all vehicles	167,535	:5,262,214:	2,190	:411,680	:	:	:	:	5,673,894	:	\$13,624

Total Annual Income..... \$13,624

(Time Element Savings cont'd)
Local Traffic Diverted Traffic
@100%

Annual Traffic Volume	New	Old	New	Old
Private Passenger cars (per year)	82,088			
Trucks, light (per year).....	66,503			
Trucks, medium (per year).....	6,716			
Trucks, heavy (per year).....	12,228			
Totals.....	167,535			
Private Passenger Cars				
Average speed (miles per hour)...	35.2	30.3		
Distance (miles).....	20.4	20.85		
Time (hours per trip).....	0.580	0.688		
Time savings per vehicle.....	0.108			
Value of savings (\$/vehicle-hour)	\$0.60			
Annual traffic volume.....	82,088			
Total.....	\$ 5,319		\$ 1,936	
Trucks, Light				
Average speed (miles per hour)...	32.2	27.3		
Distance (miles).....	20.4	20.85		
Time (hours per trip).....	0.634	0.764		
Time savings per vehicle.....	0.130			
Value of savings (\$/vehicle-hour)	\$0.86			
Annual traffic volume.....	66,503			
Total.....	\$ 7,435		\$283	
Trucks, Medium				
Average speed (miles per hour)...	28.2	23.3		
Distance (miles).....	20.4	20.85		
Time (hours per trip).....	0.723	0.895		
Time savings per vehicle.....	0.172			
Value of savings (\$/vehicle-hour)	\$1.17			
Annual traffic volume.....	6,716			
Total.....	\$ 1,352		\$105	
Trucks, Heavy				
Average speed (miles per hour)...	25.2	20.3		
Distance (miles).....	20.4	20.85		
Time (hours per trip).....	0.810	1.027		
Time savings per vehicle.....	0.217			
Value of savings (\$/vehicle-hour)	\$1.47			
Annual traffic volume.....	12,228			
Total.....	\$ 2,653		\$369	
Total.....each category.....	\$ 16,759		\$ 2,693	
TOTAL ANNUAL TIME ELEMENT SAVINGS.....			\$ 19,452	

e. Mileage Element Savings
As per tabulation which follows:

HIGHWAY PROJECT ANALYSIS

Mileage Element Savings

Location of project	MONTANA	County	CARTER
Description of Project	EKALAKA-ALZADA		
Highway number	FAS No. 323	Highway system	FA SECONDARY
Length	80.0 miles	Date of analysis	APRIL 1946

	Local Traffic		Diverted Traffic @ 100%	
	New	Old	New	Old
Distance	20.4	20.85		
Length (miles).....	0.45			
Distance saving (miles).....	556,848			
Average annual traffic (tons).....	250,582			
Annual traffic saving (ton-mi.).....	\$0.0178			
Cost (\$/ton-mile).....	\$ 4,460		\$ 7,262	
Total.....				
Surface				
Roadway surface type.....	0.193	0.276		
Saving coefficient.....	0.083		No saving	
Aver. annual traffic (ton-mi.).....	11,610,281			
Saving (\$/ton-mile).....	\$0.0015			
Total.....	\$ 17,415			
Alignment				
Curvature rating.....	4.7	0.3		
Points improvement.....	4.4			
Saving (point-ton-miles).....	51,085,236			
Saving (\$/point-ton-mile).....	\$0.0001			
Total.....	\$ 5,109		\$70	
Total...each category.....	\$ 26,984		\$ 7,332	
TOTAL ANNUAL MILEAGE ELEMENT SAVINGS.....			\$ 34,316	

f. Traffic Benefits

As per tabulation which follows:

HIGHWAY PROJECT ANALYSIS

Traffic Benefits

Location of project	MONTANA	County	CARTER
Description of project	EKALAKA-ALZADA		
Highway number	FAS No. 323	Highway system	FA SECONDARY
Length	80.0 miles	Date of analysis	APRIL 1946

Mileage Element Factors

Item		Fuel Function	Non-fuel Function
Distance savings	\$11,722 38%	\$ 4,454	\$ 7,268
Roadway surface savings	17,415 44%	7,663	9,752
Alignment savings	5,179 50%	2,590	2,589
Total Mileage Savings	34,316	\$ 14,707	\$ 19,609

Time Element Factors

Type of Traffic	Annual Value of Time Savings
Passenger cars	\$ 7,255
Trucks, light	7,718
Trucks, medium	1,457
Trucks, heavy	3,022
Total Time Savings	\$ 19,452

Recapitulation of Annual Benefits

Total Fuel Function Benefits		\$ 14,707
Non-fuel function (Mileage element factors	\$ 19,609	
benefits (Time element factors	\$ 19,452	
Total Non-fuel Function Benefits		\$ 39,061
TOTAL ANNUAL BENEFITS		\$ 53,768

g. Derivation of Quotients
As per tabulation which follows:

HIGHWAY PROJECT ANALYSIS

Location of project	MONTANA	County	CARTER
Description of project	EKALAKA-ALZADA		
Highway number	FAS No. 323	Highway system	FA SECONDARY
Length	80.0 miles	Date of analysis	APRIL 1946
$I_{ar} = \$$	13,624	K_1	$= 1.00$
$C_a = \$$	72,543	K_2	$= 2,795/14,707 = 0.19$
$B_n = \$$	39,061	K_3	$= 0.05/0.20 = 0.25$
$B_f = \$$	14,707	$K_2 K_3$	$= 0.19 \times 0.25 = 0.05$
$K_1 C_a = \$$	72,543	$1 - K_2 K_3$	$= 1.00 - 0.05 = 0.95$
$Q_s = I_{ar}/K_1 C_a =$	$13,624/72,543 = 0.19$		
$Q_{Bn} = B_n/K_1 C_a =$	$39,061/72,543 = 0.54$		
$Q_{Bf} = B_f/K_1 C_a =$	$14,707/72,543 = 0.205$		
$Q'_s = Q_s - K_2 K_3 Q_{Bf} =$	$0.19 - 0.05 \times 0.205 = 0.19 - 0.01 = 0.18$		
$Q_c = 0.707 (Q_s/Q_{Bn}/Q_{Bf} (1 - K_2 K_3)) =$	$0.707 (0.19 / 0.54 / 0.205 \times 0.95)$		
	$= 0.707 (0.19 / 0.54 / 0.195)$		
	$= 0.707 \times 0.925$		
	$= 0.655$		

Note the low composite solvency quotient value in relation to the manifest in Analysis C, sub-section 5, g. (0.765)

V. RECOMMENDATIONS

It is recommended that the central routing (Route C) be followed the location of the Ekalaka-Alzada road. Any "County-feeder" allocation by the County Commissioners off the designated Secondary System should, by vir of its high traffic volume, include the Ekalaka-Chalk Buttes road.

